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TABLE OF CONTENTS

CHARLES FELTON SCOTT AWARDED THE THIRD LAMME MEDAL

Charles Felton Scott, Professor of Electrical Engineering, Yale University, was awarded the third Lamme medal by the Society for the Promotion of Engineering Education at its thirty-eighth annual meeting at Montreal, June 26–28, 1930.

Charles Felton Scott was born at Athens, Ohio, in 1864. After graduating from Ohio State University, of which his father was President, in 1885, he took graduate work at Johns Hopkins University and, at the same time, taught in the Baltimore and Ohio Railroad Technological School. Professor Scott also received the degree of A.M. from Yale, Sc.D. from the University of Pittsburgh, and Eng. D. from Stevens Institute of Technology.

In 1888 Professor Scott entered the employ of the Westinghouse Electric and Manufacturing Company, starting in the Testing Department. In 1891, he became Assistant Electrician and in 1897, Chief Electrician. In 1904, he became consulting engineer to the Company, a position which he still holds. In 1911, he accepted the Professorship of Electrical Engineering at Yale.

While with the Westinghouse Company, Charles F. Scott was suggested as the man best fitted to assist Nikola Tesla in his world-renowned work on alternating currents. His early experience in the Company brought him in close contact and coöperation with Benjamin Garver Lamme, by whom the Lamme Award was established. Professor Scott's early interest in educational development led to the establishment of the Westinghouse Club. Thousands of student engineers have benefited by the facilities of the Club, and many more thousands have been aided in their advancement by the engineering data and inspiration furnished by reading the pages of the *Electrical Journal*, "The Magazine of the Young Engineer," which he also founded.

While his international reputation began with his invention of the "Scott connection" of transformers, there is scarcely any field, no matter how small, which forms a part of the general science or the profession of electrical engineering in which Professor Scott has not made some worth-while contribution, in recognition of which, in the past year, he was awarded the Edison Medal by the American Institute of Electrical Engineers.

His foresight, while President of the American Institute of Electrical Engineers, led to the development of sections and the estab-

CHARLES FELTON SCOTT

Recipient, Third Lamme Medal, Society for the Promotion of Engineering Education, June 27, 1930

lishment of student branches. He had the vision which culminated in the erection of the Engineering Societies building and the Engineers' Club in New York, carrying on the negotiations with Andrew Carnegie. He was Chairman of the Building Committee. He was instrumental in forming the Federated American Engineering Society, and is a member of its governing body, the American Engineering Council. In 1921 he was elected President of this Society, and his work, that year, led to his re-election in 1922. No man before him or since ever held that office more than one year.

Professor Scott's vision of broadening and enriching engineering education led to the investigation of that subject by this Society. He has been Chairman of the Board of Investigation and Coördination which directed that project. He secured the necessary funds for this work—both for the initial investigation and later for the further study of the subject. He has worked untiringly and unselfishly for the promotion of engineering education.

A FEW REFLECTIONS

By HAROLD S. BOARDMAN

President of the Society

Does the present day educator take himself too seriously? In this day of intense endeavor to develop the best ways of doing things and of following the slogan "efficiency" are we losing our perspective and letting the present and our ideas of the future overshadow the past? In our desire to become educated ourselves, are we worshipping research and the Ph.D. degree and allowing only the overflow to reach the undergraduate student? Are we using human material to experiment upon in our laboratories of life in an attempt to put our pet theories of education into practice? Are we riding a hobby when we make mathematical deductions by use of personnel systems, intelligence tests, placement examinations, et cetera, and say to this student thou shalt and to that student thou shalt not?

These are only a few of the questions that crowd my mind more and more as the years pass by, and I wonder at times if after all we are doing our work better or worse than we did twenty-five years ago. The present age of educational experimentation has been pregnant with so much in the way of reports and dissertations upon this and that phase of the subject that one is likely to become lost in his endeavor to arrive at logical conclusions based upon so many premises, many of which are diametrically opposite. It is true that there are different ways of doing things and we may arrive at certain objectives by various routes. There are, however, certain fundamental principles which should be our guide in teaching the young and untrained mind. These principles have stood the test of time and apparently cannot be replaced by substitutes if we would develop the scholar, and I take it that a high type of scholarship nowadays indicates ability in engineering as well as in arts or in the older professional curricula.

To me, one of the most important requirements in teaching is the development of a personal relation between teacher and pupil. There is a certain philosophy of education which must be absorbed by the pupil in order for him to become a real scholar and finally a power in his profession, and much depends upon the attitude of the teacher. It has been said that "Science without philosophy, facts without perspective and evaluation, cannot save us from havoc and

despair. Science gives us knowledge, but only philosophy can give us wisdom.'' In the ancient days, Socrates taught that there is no real philosophy until the mind turns round and examines itself. And again, '' Woe to him who teaches men faster than they can learn.'' Socrates, Plato, and Aristotle gave to their pupils the best they had and did so by a contact so personal that each pupil could absorb fundamental principles without losing his own identity, and all the while grew in power to think for himself. Can we do better in this enlightened age than to follow some of the methods of those old philosophers whereby real scholars were created?

I fully realize the obstacles in the way of personal contact in this day of mass production, but from my own observation I find that too many of our teachers fail to grasp the student view point with the result that a constantly widening breach is created between student and teacher which has a tendency to develop anything but a spirit of good feeling, without which cooperation is impossible. Too many teachers appear to put their chief efforts upon the development of themselves and use their position as a stepping stone in their upward career, giving their students the benefit of their knowledge in so far as they can with convenience. Too many teachers, having arrived at a position of responsibility, look down from the heights instead of coming down to mingle with the crowd. To be a scholar is a fine thing if it does not, through specialization, narrow the horizon so that one forgets fundamentals and the good things of life and becomes interested only in some phase of his particular field. In fact scholarship in the broad sense is quite necessary for success in any field of scientific endeavor.

I have often wondered if a definition of the term scholar could be given which would fit not only the doctor and the lawyer but the engineer and the candlestick maker as well! Some time ago, I happened upon a definition which seems to apply. ''Scholarship is a development of the man who knows and who on the basis of what he knows can think.''

I never weary of telling of my ideal of the highest and happiest as well as the most productive type of scholar as expressed by President Hibben of Princeton, in a discourse upon what he called the ''Flower and Fruit of Knowledge.'' He defined the Fruit of Knowledge as the bare results of scholarly investigation, accumulated facts, generalizations, formulae and hypotheses based upon these facts and resulting from the brooding mind. If, however, the effect produced upon the inquiring mind by daily and hourly contact with truth is that of deepening, enriching and refreshing his spirit there is a consequent refinement and elevation of thought and he has acquired the Flower of Knowledge. You and I have known people who have obtained the Fruit of Knowledge, but who have

utterly failed to appreciate what is meant by the Flower of Knowledge. I know that your mind will pick out some teacher who was a special inspiration, and who was the means of creating within you an idealism which has left its mark. Such teachers knew the Flower of Knowledge and in knowing enriched not only their own lives but yours and mine. Such men never grow old. They may run down like a clock that is not wound, but their minds are always young no matter how much of truth they may discover.

ENGINEERING LEADERSHIP *

By R. I. REES

President of the Society for the Promotion of Engineering Education; Assistant Vice President, American Telephone and Telegraph Company, New York City

No one could have attended the impressive ceremonies in commemoration of the 50th anniversary of the American Society of Mechanical Engineers, or listened to the contributions of scientists and engineers from all parts of the world, without being profoundly impressed with the conviction that this is an age of engineering leadership. And out of the inspiration of that great meeting came the engineers' answer to the challenge "Whither Mankind?" Scientists, engineers, engineering teachers have viewed, clear-eyed and unafraid, our present social structure, and have given the straightforward answer, "Toward Civilization."

No one of them, writing of the foundations upon which our present industrial civilization rests, whether it be power, giving each American one hundred slaves to do his bidding; transportation, which has been conquering distance through land, sea, and air; or communication, which has eliminated both time and distance; or architecture, with its new contribution to beauty, has failed to realize that, involved in all of this miraculous technological progress, there is a responsibility for the social consequences of these great developments in engineering leadership.

There is no pause in the progress of science. One would think that engineers and scientists in their climb onward and upward might reach a plateau, rest, and permit the world to catch up with them. But no; only last week at Cornell, Professor A. R. Compton gave us a picture of the interior structure of the atom which he has seen, making clear the nebular haze of electrons surrounding the nucleus with his beautiful analogy of the halo around the moon; and Professor S. Zwicky of the California Institute of Technology told of discoveries concerning the nature of crystal structure which those who know believe may be of great practical benefit in the strengthening of metals and in making possible improved methods of insulation. How gratified Faraday would be to know of the tremendous development of power brought about by his discovery

* Presidential address delivered at the thirty-eighth annual meeting of the S. P. E. E., at Ecole Polytechnique and McGill University, Montreal, Canada, June 26–28, 1930.

of the relations between electricity, magnetism and motion, and of Einstein's near realization of his dream that all manifestations of nature's energy, electricity, magnetism, heat, light, gravitation, are fundamentally the same. Hasn't Dr. Millikan happily symbolized it all as "the sun's fire?"

So the engineer's mastery of energy and material things must go on. He cannot pause nor shirk his responsibility, for through the character of his leadership, he has brought upon himself the responsibility for our present social order. He has brought about our industrial civilization and he must accept leadership which will keep for mankind the benefits which it gives and contribute to the suppression of the evils which have accompanied those benefits.

To insure this steady march of progress towards civilization requires industrial statesmanship of the highest order. While the world cannot demand, nor can the profession furnish, more than a reasonable proportion of executive leadership in industry, yet the engineer's analytical method of thinking and his passion for truth can and will have a great influence on all industrial leadership. Last year Dean Kimball gave courageous and convincing reply to the critics of this technological age. Yet no one knows better than the engineer, the weaknesses of structure in industry and the deterrent influence of these weaknesses on our national progress and prosperity. He knows that the fundamental difficulty in industry today is lack of coördination. The truth of this is best demonstrated by the undoubted success of industries which are well coördinated within themselves and in their relations with others in the same field of production. But what of the lack of coördination in an industry like the textile industry, where a duplication of the New England plants in the South has developed a desperate condition of overproduction which threatens the life of that industry? What can we say of the criminal waste which is going on in the oil industry through lack of coördination? The leaders in that industry are the first among those who deplore the conditions which exist, but they seem helpless to correct them. What sort of condition is it that, when a pool is discovered, permits individual owners, clamorous for their share, to sink twenty to a hundred wells when two or three would suffice. As we know, legal restrictions are largely to blame here for the lack of proper control of production. Industrial statesmanship should attack this problem with government, and fight for early solution if we are to hold our wealth in oil from early exhaustion. Of course, we know that lack of coördination through overproduction is menacing the farmer with ruin. Last week when I was visiting the Summer School of Engineering Teachers at Carnegie Institute of Technology, in conversation with President Baker, he offered this startling but most enlightening suggestion for bring-

ing about the coördination which the coal industry so sadly needs. He stated that the problem can only be solved through intensified scientific and engineering research leading to the extraction of all the products which come out of crude coal and improvement of fuels through technological processes, so that the future will see no further use for the raw product. This will cause a concentrated control of production, and bring about a high degree of coördination in the long-suffering coal industry. These are illustrations of some of the weakest parts of our industrial structure. Many illustrations in smaller fields of endeavor might be included in explaining the frequently heard expression, "Profitless Prosperity." Many of the most efficient in this class are facing annihilation because of cut-throat competition and lack of coördination.

The reason that this is peculiarly a problem within the responsibility of engineering leadership, is that engineers, through the development of technological processes, have solved the production problem. Productive capacity in this country to-day actually exceeds the capacity for consumption. Coördination which will relate supply to demand, is the imperative problem which calls for solution.

The problems of distribution are still far from correct solution. No one can deny that the wide spread between cost at point of production and price to the ultimate consumer is altogether too wide. This problem, of course, involves efficient studies of economy in the whole transportation industry, but it involves more than that in the determination of the points from which distribution should be made. Does there seem to be any reason that San Francisco, or even Chicago, should send steel products to Pittsburgh, and Pittsburgh in turn ship steel products back to these cities? Is there any reason, in a proper scheme of national coördination, why plants for products in major demand should not be so located as to supply a given territory at a minimum cost for distribution? These are questions which the engineer should be preëminently fitted to answer.

Another condition which is crying out for relief is that of unemployment. The engineer, through high leadership in technological fields, can not deny his measure of responsibility for creating this condition. The term "technological unemployment" symbolizes that responsibility. Here is the darkest shadow thrown across the picture of our national prosperity and most obscure are the means of bringing light where that shadow falls. It is another challenge to engineering leadership. I have no solution to suggest and can only raise questions. Can engineers be alert enough when their machines displace workers, to develop new products to tempt the consumer, new processes or new services to absorb the displaced labor? Can this reiterated principle of coördination impell our industries

to act in concert and to devise ways and means to make employment universal and the wage scale adequate? Will the time ever come when no worker will have to seek for a job, but simply ask where it is?

As I said in the beginning, all I can do is to bring before you some of the problems now bearing down upon our industrial civilization, which are in the thoughts of all of you, and to challenge engineering leadership in the solution of them.

An outstanding leader in engineering is now the leader of our nation, and we know that he is thinking of all these things and seeking right solutions. For he has said, "The outstanding problem and the ideal of our economic system is to secure freedom of initiative and to preserve stability in the economic structure in order that the door of opportunity be open to all citizens; that every business man shall go about his affairs with confidence in the future; that it shall give assurance to our people of a job for everyone who wishes to work; that it shall, by steady improvement through research and invention, advance standards of living to the whole of our people."

Of course, in all this discussion of coördination it is understood that industrial statesmanship must accept with whole heart and all sincerity the new objective of industry—not profit, but service—a service which means determining the needs of man and providing them in the highest quality at the lowest possible cost.

Throughout this meeting we shall be considering the subject of the teacher and his work. Engineering leadership is born in engineering education. A great responsibility rests to-day upon you as teachers of engineering. You are the real leaders in engineering, for you will equip the young engineer with the elements of knowledge which will best enable him to take up his life's work and carry it forward with the confidence you have given him in his own intellectual development. Industry has come to value in the graduate more than all else, a firm background of fundamental science and engineering principles, realizing that it is the responsibility of industry itself to train the young men in its own specializations. One demonstration, of course, of engineering leadership in education, is the wisdom shown in the structure of the curriculum. The evidence which Dr. Bishop will present shortly, confirms your wisdom in this field.

Speaking for the moment from the viewpoint of industry, we who make a conscious effort to employ the engineering graduate, secure him, we hope, for future leadership. We are not employing him for the small job that is available to-day. We want him when coming to us, to attack each problem in a thoughtful way, to relate the small job first assigned to him, to those of his associates and of his superiors, so that he will grow in ever broadening comprehen-

sion. Then, when he comes to that period ten or fifteen years hence, when he has passed through the lower supervisory levels in staff or operations, and emerged into an executive position, he will know how to respond to the demands imposed on him and be able to solve the serious problems which confront him. With your help and his subsequent experience, he will then have prepared himself for the higher realms of engineering leadership, yes, of industrial statesmanship.

While you are responsible for his earlier development, you will help him to develop character; you will give him fundamental knowledge; you will teach him how to get along with his fellows, and give him a realization that the greatest problem which he will face in his life's work is that of human relationships; if he has a bent for scientific research, you will encourage it, guide him and direct him in graduate work. From you he will get the realization of the value of truth and apply those values in engineering method of thought. Through you he can face the world with trained intelligence. Finally, with your constantly improving standards of teaching, you are developing within the student, a true culture. Those present who heard the inspiring talk of Dean Anthony before the Summer School in Drawing last Friday, know what I mean. He denied that culture comes from the subject, but asserted that it develops out of the manner of teaching any subject. More and more has science become the basis of intellectual advancement, and culture may come out of the proper teaching of drawing, descriptive geometry, mechanics, and thermodynamics, and in fact all subjects in the engineering curriculum. We will all agree, I am sure, that this type of curriculum in higher education can inspire in the student a higher and broader vision of the realities of life.

Therefore, as developers of the world's future leaders, you take your place in engineering leadership, and in fundamental work in research you fortify that position. There can be no nobler profession than that of teacher—developer of men. There is a constant, enduring, and ever present inspiration for the teacher in his work.

DISCUSSION:

A. A. Potter: We are very greatly indebted to the President of our Society, Dr. Rees, for a very clear conception of our responsibilities and opportunities as teachers of engineering, to train leaders who will be able to direct wisely the great developments in science and in engineering, engineers who, as Dr. Rees stated, will insure a steady march of progress toward civilization.

As for our engineering curricula, from the standpoint of the industries, it is most encouraging for us teachers to learn from

General Rees that he considers them well suited to develop in students a broad vision of the realities of life; also, that he feels that engineering leadership is borne of engineering education. However, if our curricula are to train engineers who can improve our social order, it is our greatest responsibility as teachers to develop character, to train for clear thinking, and to inspire in our students an appreciation of the human relationships which must exist in all problems confronting the engineer.

R. L. Sackett: President Rees has spoken from the point of view of a leader in and of industry, and in doing so he has paid us a high compliment, and at the same time placed on us a responsibility so great that it is almost overwhelming. He has pointed out certain weaknesses of the industrial structure of which he is a part, and has called upon the engineer to participate in the correction and the prevention of some of the defects of our social organization, which is so closely related to our industrial setup.

He has, in reality, asked the engineer to become the practical economist of the future. He has asked the engineer to assume a certain type of social leadership which he formerly refused as a profession. He has pointed out to us that a certain new form of coöperation and coördination will be necessary in order to remove some of these stains from the body politic. By inference he means that with that coördination there must be further limitation of our liberties, because democracy itself means the restriction of the liberty of the individual to do as he pleases, and if society is finally to see clearly these facts, it is, I believe, going to be through the position which the engineer takes as he faces these problems, stripping them of their non-essentials, of their local political appeal, as President Hoover has attempted to do in the presentation of the problems which he has placed before the American public. Certainly the engineering professions ought to support the President of the United States in that attitude toward these great political problems.

If the engineering teacher is to be a force in this future evolution of society, he then must accept a very great responsibility. And, if he is to become to the student of the future that more nearly perfect guide and philosopher and friend, he will be something more than a teacher of technique. He will be a man who contributes out of his innermost self to the development of the cultural side, to the development of that interest in these larger problems which the engineer must begin to think about if he is to assume these larger responsibilities.

F. E. Turneaure: I have been very much impressed by the expressions of our hosts and our President, regarding the great re-

sponsibility of the engineering teacher. I have also thought back over past history, as a man of my age is apt to do, and remarked the great contrast between the number in this audience and the character of our address, coming from a man in industry, with the meetings and programs of twenty or twenty-five years ago, when I think our work was not so greatly valued by industry as it is now. Nor were our responsibilities so highly rated as they are at the present time.

Our addresses from our hosts and our President, show pretty clearly that we have got to do our best along educational lines, not alone in applied science, but in human relations, and should lay more emphasis upon the latter than we have done in the past. An engineer needs to be more than a man who figures out things; he must also be articulate, and must understand human relations. Perhaps we forget the very small proportion of our voting population that thinks scientifically and rationally. Our big problems are not often solved; our political problems are very rarely along strictly rational lines, and I believe if our engineering graduates would appreciate that fact more thoroughly and take into account the element of human relations, they would have more influence in getting those problems solved in a rational manner.

I cannot help but think, particularly by reason of the fact that one of our hosts is L'Ecole Polytechnique, of the great influence of French engineers in public life in France, much greater, apparently than has been the case in this country, but I anticipate a gradual change in this respect in the future. Our present President of the United States is an example which I hope will be repeated, but I think we all realize that some of his difficulties that he is encountering are due to the fact that many of our problems are not solved rationally.

President Frank, of the University of Wisconsin, is prone to express his belief in the great need of getting more science, more of the engineering method, more rationality into the solution of our economic and social problems.

So I think we can return from this meeting with a more thorough realization of our responsibility, and also with a considerable amount of encouragement in our big job of education. We have a great deal to thank our President for in focusing our attention on this particular phase of our job.

ADDRESSES OF WELCOME

By AURELIEN BOYER

Principal and President of the Governing Board of L'Ecole Polytechnique

You have taken as watchword for this meeting "The Teacher and His Work." Will you allow me to tell you in a few words of a simple lesson I received some thirty years ago, and of the teacher who was a very humble man who probably does not know to this day what influence this lesson has had on my whole career.

In 1899 the Canadian Government, at the request of authorities of the Yukon Territory, and later to accommodate the military authorities of Alaska, had undertaken the construction of a telegraph line from Dawson City and beyond to the boundary of Alaska at Fort Egberton and South to Quesnel in the old Caribou District of British Columbia, a distance of over 1700 miles. My mission was to find a route through the wilderness by valleys and passes through the mountains for this telegraph line. My only companion in preliminary explorations was an Algonquin Indian from the Province of Quebec who came to me recommended by the Hudson Bay Company. He had a long name, so we called him Pete, for short. This Indian was so at home in this strange and new land, that I had come to look upon him more as a host and a friend rather than a servant. One day in the summer of 1900, we were sitting alone together on the edge of a basaltic plateau, South of the Stikine River, at an altitude of about 4000 ft. just above the timber line. We had followed around the base of this plateau for several days and had just climbed to this spot. While resting I had plotted in my note book the route we had come over, and had made a sketch of the country around us. I can remember to-day, as if I was there yet, the beautiful panaroma that stretched before us: To the West and South in the distance, nothing but lofty snow capped peaks, and I remember wondering how we could ever get through, below us the depth of a valley where I could see a stream, white and rich with the grists of the glaciers, winding its way through the dark green of the balsams of the forest. Immediately below us and nearer, immense hexagonal crystals of basalt breaking through the drift and forming gigantic steps or palisades, and to the northeast for a long distance, the flat table top of the plateau, the feeding ground of caribou herds. I had laid my prismatic compass on the moss, beside me, pointing towards the camp we had left

several days ago, and where we had decided to return by taking a short cut across the table land. I asked my Indian companion what direction we should follow to go back, and he pointed within a few degrees of the bearing which my compass indicated. There was a question I had often wanted to ask him, but every time I had hesitated, as it seemed to me each time a silly question to ask. On this occasion I was so amazed at the accuracy of his judgment, that I asked him: How do you do it Pete, have you got a sixth sense for direction? He paused for a moment, and I could see lines of pity and irony around his mouth. He answered, "No, we, Indians, have not got a sixth sense, *we look where we go.*" Then he told me how, he did not observe the landscape in front of him only, but to the right and to the left, that he often stopped and looked back, so as to absorb the lay of the land from every possible angle. He added, the white man he goes where he looks, swayed to one side or the other by the beautiful colors of butterflies, or the antics of small animals that cross his path; when he turns to go back, he is surprised to find the scenery before him entirely new, and he is lost, because he never looked back.

Gentlemen, when I observe this distinguished and numerous assembly, and when I think of the wealth of knowledge and the wealth of experience which all of you together have brought to this meeting, and when I take into consideration the extent of your program, I wonder if again the rôles have not been changed and if, instead of being the host that receives you, we are not the guest that will sit at your table.

Although inspired by the French schools of engineering, and dominated by our Latin mentality, we have nevertheless on several occasions let ourselves be guided by your advice, through your yearly proceedings and your Summer schools. And if I am allowed to carry the parallelism further, I cannot help but compare you to my old guide who on several occasions had pulled me out of difficulty, and whom I had come to love and respect as a true friend.

Is not the object of your society to "look where we go" and year after year have you not paused to look back? As I also look back, I hear the sounds of an echo, "Teach Fundamentals" repeated from year to year, which has been a great comfort, a great encouragement to us. To-day and the next two days we will be sitting together on the high plateau to which you have raised yourselves through your efforts, looking to the right, looking to the left, looking forward and bending over the past; again we have set our compass by our side and we are waiting to see if your hand will point in the direction we have chosen, but whether it points to the right or to the left of our course, we will try to follow you to the extent of the means at our disposal and within the limits of our influence.

It is with this spirit, with these feelings that I have the pleasure, and I deem it a great honor, to extend to you on behalf of l'Ecole Polytechnique our heartiest welcome.

By SIR ARTHUR CURRIE

Vice Chancellor and Principal, McGill University

Let me at once express my deep sense of the honor that is mine in being privileged to address the members of the Society for the Promotion of Engineering Education. In the name of McGill University I bid you a most cordial welcome to Montreal and to this University. It is appropriate that I, as principal, should do so. Our engineering school is one of our best and most useful schools. Though we are proud of it, proud of its staff, proud of its graduates, gratified at the part they have played in the development of this country, in the contribution they have made to increase the measure of health and prosperity and the comforts of living enjoyed by our people, we are not unmindful of the fact that greater efficiency is the watchword, not only of the engineer but of the engineering school. If he who welcomes you should be an authority on engineering education, then I am badly chosen. But if he is one who appreciates the engineer for what he has done, can do, and will do, then I am satisfied to be chosen, for I yield to none in my admiration of him and in my sense, bordering on awe, even on veneration, of the magnitude of his achievements and the honored place he occupies, or should occupy, in our national life.

There is now a great bond between the university and the engineer. It was not always so. In fact, I do not think it is too much to say that engineering is a profession—a highly respectable and important profession—because the university made it so. On the other hand, it would not be unfair to say that from the time the universities undertook the training of engineers, they became vastly more useful institutions.

The term "Applied Science" tells the story. There was a time when men attended universities to fit themselves—if they regarded university training in any other light than as a decoration—to serve the state as teachers, as preachers, as lawyers, as civil servants, as parliamentarians, as writers. University education concerned itself with a study of languages and literature, of history, of mathematics, of philosophy—those subjects which we term The Humanities. But deeper study of the mysteries of the natural sciences, of physics, of chemistry, of astronomy, made man curious to find out and determine whether the forces of nature could be controlled and harnessed and made to serve him. Man has always been willing to struggle with nature, to master her secrets, to bend her to his will.

Nature has always been a challenge to man. She was shy, deep, mysterious, powerful and beautiful. She excited him, dared him, revealed her secrets grudgingly, taunted him, inspired him, rewarded him, but one cannot yet say that the union is perfect and complete, though, so far, it has been happy and interesting, highly productive of good things and promising many more.

No field of university endeavor has yielded results comparable to the knowledge acquired with regard to the constitution of matter and the forces working within nature. The greatest march forward across the fields of time has been made in the last one hundred years; in the last fifty it has been in quick time; in the last twenty we have taken it at the double. If we think of the application of natural forces, of what that has done for productive industry, for the transportation by land and water, when we consider the means we now possess for the transference of thought, irrespective of distance, and of the prodigious stimulus to population as well as wealth which the knowledge of these natural forces has produced, we shall think of the most extraordinary phenomena experienced in all the ages of human history. Yes, the great advance of knowledge in modern times has been in the domain of science. As Lord Bryce once said, "Look in all other fields, and you will find no field in which, during this century and a half back, so great a crop and precious a crop has been reaped as in the field of natural science." The engineer has helped to reap that crop.

I might take time here to dilate upon man's victories over natural forces, but, after all, rewards of these victories are apparent on every hand. People of all classes appreciate that our manner of living, our buildings, our modes of travel, our daily routine of life, have been completely altered, even in our own lifetime, and that in these tremendous developments engineers and engineering have played the greatest part. New means of communication, new sources of power, have helped to bring about an almost incalculable economic change. International politics have been revolutionized by the telegraph, the wireless, the aeroplane, and the end is not yet.

Obviously, with all these changes, education had to change, too. change in system, in outlook and in purpose, if it were to keep pace with the new environment. The deeper waters of ancient knowledge and experience flow on as before, but they have changed in color and content because to them have been added the streams of new knowledge and new learning which have changed the face of the world in which we live. Education, particularly higher education, once the privilege of the few, is now within the reach of all, while the field it covers has broadened considerably, even so much as to make some of us wonder if at times we see the trees only and do not observe the forest.

Let me make brief reference to engineering education. What has been the knowledge that has enabled the engineer to achieve so much? The answer is, a knowledge of forces of nature and the ability to see how this knowledge can be made to serve the problems of mankind in all their infinite variety. It follows, then, that in the education of an engineer provision must be made not only for the teaching of these sciences, but also of training men in the methods of scientific research, of interrogating nature, of adding new knowledge to our present store, thus broadening out the field for further advance into the unknown and looking to a more complete mastery of the forces of nature, to the end that we may achieve for mankind results that at present live only in the land of dreams. This field of research in pure science is apparently illimitable, and the unravelling of the secrets of the material universe in the faith and hope that we may finally reach a completed understanding of the intricate and wonderful pattern of the "living garment of deity" is beyond all doubt a task not only of entrancing interest, but one of highest and noblest aim that can engage the mind of man.

The first obligation of an institution for the training of engineers is to see to it that capable men and sufficient facilities are provided for giving them a knowledge of the natural sciences and to implant in their minds a desire to consider the way in which that knowledge can be applied to the improvement of man's estate.

An engineer is a professional man, conforming to those ethical standards which should characterize professional life. He is an educated man. At least, he must have a sound scientific training and above all he should have enthusiasm and imagination. He should be a creator. If he lacks the power of vision, if he cannot create, he becomes little more than a superintendent of works. It is hard to give men the power of vision, but at least I think you should be able to keep the deadwood out of your profession. "Imagination is the ruler of the human race," said Napoleon, and he conquered the hosts of his enemies. His deadliest opponent was a man who possessed the soul of a poet, though he thought in ships and guns. The secret of the "Nelson touch" was the vision which let Nelson presage the confusion his tactics would create in the opposing fleet, and enabled him to forsee a victory won as much by moral as by physical force. Imagination has had no less a share in the conquest of nature. Canada furnishes many examples. The story of the Intercolonial railway and the Canadian Pacific railway are dramatic chapters in our history. Such imagination is the real power which has brought your own profession to the place it occupies today on this continent. That imagination will enable you to do still greater service. The task of the engineer is far from being over. The world has many problems which we must look to

him to solve. Our cities have become hives of teeming millions. How are these crowds of human beings to be fed, clothed, and carried from place to place? How are they to be housed in healthy surroundings, furnished with heat, light and water? How can the life of the people be given all the ameliorations that science alone can give it? The problem of human relations is one of vital interest to the engineer, and to him we must look for help and guidance. In our social life, our industrial life, our business life, our economic life, the engineer has played, and still more in the future will play, a most important rôle. His accurate technical knowledge has made him a leader in business and manufacturing. He must work hand in hand with the economist. His counsel is sought by the banker and the statesman. How necessary is it, therefore, that his education and training should be the acme of excellence!

Gentlemen, you have come to consider a most important problem, one of those problems that concerns a much larger group than the members of your profession and the schools where those members are trained. Keep your standards high. Forget standardization and concentrate on standards. Insist that the courses leading up to the engineering degree are not too highly specialized or, rather, that while highly specialized knowledge is essential, it is not everything. There should be a broad general culture basis on which the superstructure of specialism is raised. I believe that in an engineering course, hand in hand and side by side with the technological instruction should go some history, some literature or literary studies, and much economics, especially with those branches of the subject which deal with the relations of labor and capital, with the all important question of bonds, stocks, debentures, balance sheets, and the financing of great industrial corporations.

Between us, we have a great responsibility for we must try to turn out men, of whom it may be said, as it was said of Alexander Holley, "He was great in his far-seeing apprehension of the utility of things."

REPORT OF INVESTIGATION OF ENGINEERING EDUCATION, 1923–1929, VOLUME I

The first volume of the final report of the investigation of engineering education was completed in the spring and was sent free to all members of the Society who had paid their dues. If you have paid your 1930–31 dues and have not received a copy of the report, please notify the secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa., and a copy will be sent to you.

The findings and preliminary reports of the investigation which had been printed, from time to time, in THE JOURNAL OF ENGINEERING EDUCATION, were brought together, revised and supplemented in the present complete report.

Volume II will be published during the current year and will be sent free to all members whose dues are paid.

MINUTES OF THE REGULAR SESSIONS OF THE THIRTY-EIGHTH ANNUAL MEETING OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

The thirty-eighth annual meeting of the Society for the Promotion of Engineering Education was held at Ecole Polytechnique and McGill University, Montreal, Canada, Thursday, June 26, to Saturday, June 28, 1930. The keynote of the meeting was "The Graduate and His Work."

On Wednesday evening at dinner, there was a meeting of the Council at the Mount Royal Hotel, and another meeting at breakfast on Saturday.

Registration headquarters was in the Main Hall, Arts Building, McGill University. There were 485 members and guests registered.

On Thursday morning, June 26, nine conferences were held:

Coöperative Engineering Education: D. C. Jackson, Jr., Chairman.

- Railroad Work for Coöperative Students. J. E. McDaniel, Georgia School of Technology.
- Coöperative Work in Aeronautical Engineering. F. K. Teichmann, New York University.
- Engineering Education in School of Business Courses. George Filipetti, Columbia University.
- An Experiment in Industrial Education. G. B. Thomas, Bell Telephone Laboratories, Inc.
- An Industrial Viewpoint of Coöperative Training. E. B. Roberts, Westinghouse Electric and Manufacturing Company.

Drawing: Thos. E. French, Chairman.

- Echoes from the Pittsburgh School.

Electrical Engineering: Paul Cloke, Chairman.

- The Correlation of Electrical Engineering Education with Electrical Industry. Fred H. Pumphrey, Rutgers University.

English: Sada A. Harbarger, Chairman.

- Some Developments on the Teaching of English in the Technical Schools of the United States. J. Raleign Nelson, University of Michigan.
- Experimenting in English with Engineering Students. R. del French, McGill University.

General Discussion: Comparison of Objectives and Methods in the Teaching of English to Technical Students in the United States and Canada.

Industrial Engineering, E. B. Norris, Chairman.

Can Industrial Engineering Be Taught? John M. Carmody, President, Society of Industrial Engineers, Editor, Factory and Industrial Management; and Allan H. Mogensen, Assistant Editor, Factory and Industrial Management.

A Study of Some Phases of Shopwork in Engineering Curricula. R. L. Sweigert, Georgia School of Technology.

Machine Design: Frank L. Eidmann, Chairman.

Theoretical Considerations in the Design of Gear Teeth. F. A. Mickle, University of Michigan.

To What Extent Should Problems Involving Vibrations, Critical Speeds and Stress Analysis of Advanced Type Be Considered in Undergraduate Courses?

Discussion led by R. C. H. Heck, Rutgers University.

The Relative Value of the Teaching of Machine Design with and without the Making of Drawings.

Discussion led by W. V. Dunkin, Georgia School of Technology.

Mathematics: William J. Berry, Chairman.

Geometry, Its Place in the Curriculum and Methods of Presentation. Louis O'Shaughnessy, Virginia Polytechnic Institute.

The Teaching of Calculus. Egbert J. Miles, Yale University.

The Application of Mathematics to the Problems of Engineering. Thornton C. Fry, Bell Telephone Laboratories, Inc.

Tentative Plans for the Proposed Summer School for Mathematics to be held by the S. P. E. E. in 1931. H. P. Hammond, Director of S. P. E. E. Summer Schools for Engineering Teachers.

Mechanics: A. P. Poorman, Chairman.

A Study of the Correlation of the Student Grades in Mechanics with his Grades in the Prerequisite Subjects.

Percentage of Failing Grades in Mechanics.

Mining and Metallurgy: W. O. Hotchkiss, Chairman.

Mining and Metallurgy Curricula.

Reports of these conferences will be published later in the JOURNAL OF ENGINEERING EDUCATION.

THURSDAY, JUNE 26, 1930

The opening session of the thirty-eighth meeting was held in Moyse Hall, Arts Building, McGill University. The meeting was called to order by the President of the Society, R. I. Rees, Assistant

Vice President, American Telephone and Telegraph Company, New York City. Our hosts, Ecole Polytechnique and McGill University, were represented by Aurelien Boyer, Principal and Member of the Governing Board, and Sir Arthur Currie, Vice Chancellor and Principal, respectively, who welcomed us to these institutions and to Montreal. President Rees responded for the Society.

Vice President Hitchcock took the chair and President Rees delivered his Presidential Address, "Engineering Leadership." In this address he "made a forceful plea for engineering leadership, and did not hesitate to call attention to certain fields in which the engineer had, as yet, made little progress, but where his services were grievously needed. In particular he spoke of the need for giving the same attention to the problem of distribution that the engineer had given so successfully to production. In referring to the problem of unemployment he called for an earnest consideration of it by engineers and asked, "Will the time ever come when no workers will have to seek for a job, but simply ask where it is?" In dealing with these subjects, President Rees emphasized the peculiar fitness of the engineer to deal with them, and also his responsibility to society to offer solutions. Specifically he reminded his audience that as developers of the world's future leaders they had an important rôle in engineering leadership which they could fortify through fundamental research, and closed by stating that the constant, enduring, and ever-present inspiration for the teacher lay in his work."

This address was discussed by A. A. Potter, Purdue University, R. L. Sackett, Pennsylvania State College, F. E. Turneaure, University of Wisconsin, and E. A. Hitchcock, Ohio State University.

President Rees resumed the chair and Secretary F. L. Bishop presented the results of the investigation of engineering education which gave us an opportunity to compare our progress to-day from the point where we were five years ago. The data were collected from questionnaires which had been sent out by the Office of Education, Department of the Interior.

At four o'clock, McGill University entertained the Society at a garden party held on the campus.

In the evening, the report of the Committee on Industrial Relations of the Institutional Division was presented at a meeting at which the chairman of the Committee, R. L. Sackett, presided. This report was entitled "Can the Engineering Student Be Taught to Manage Men?", and was presented by Elliott Dunlap Smith of Yale University. The report was discussed by Sam A. Lewisohn, New York City, Jos. W. Roe, New York University, J. A. Randall, Rochester Mechanics Institute, A. L. Williston, Dedham, Mass., and President R. I. Rees.

FRIDAY, JUNE 27, 1930

The second session was held at 9:30 A.M., in Moyse Hall, Arts Building, McGill University, with President Rees in the chair. This session was devoted to "Personal Relations of Teachers." The subject was divided into five groups with the following speakers: "With Fellow Members of the Faculty," J. W. Barker, Lehigh University; "With Students," C. L. Kinsloe, Pennsylvania State College; "With the Community," Gen. C. H. Mitchell, University of Toronto; "With Industry," R. E. Doherty, General Electric Company, (paper read by E. E. Johnson in the absence of Mr. Doherty); "With National Engineering Societies," by Calvin W. Rice, Secretary, American Society of Mechanical Engineers.

The Nominating Committee, composed of past presidents and the elective members of the Council whose terms expire next year, presented the following report:

For President: H. S. Boardman, President, University of Maine.
For Vice Presidents: C. F. Harding, Purdue University, R. A. Seaton, Kansas State Agricultural College.
For Treasurer, W. O. Wiley, John Wiley & Sons, Inc.
For Secretary, F. L. Bishop, University of Pittsburgh.
For Members of the Council to Serve Three Years:
L. E. Akeley, University of South Dakota, Vermillion, S. D.
R. E. Doherty, General Electric Company, Schenectady, N. Y.
W. E. Farnham, Tufts College, Tufts College, Mass.
Augustin Frigon, Ecole Polytechnique, Montreal, Canada.
T. J. Hoover, Stanford University, Stanford University, Calif.
F. V. Larkin, Lehigh University, Bethlehem, Pa.
J. E. McDaniel, Georgia School of Technology, Atlanta, Ga.

Upon motion the nominations were closed and the Secretary cast the unanimous ballot of the Society for the nominees.

Past Presidents Turneaure and Potter escorted President-Elect Boardman to the platform. Mr. Boardman said: "I have been connected with this Society for twenty-seven years. I have always taken a very great interest in it and I count it an honor, a very distinct honor, to become its president. I stand before you with humility and the great desire to do my best during the coming year for the interests of the Society."

L'Ecole Polytechnique entertained the Council and invited guests at a luncheon at the Cercle Universitaire.

The third session was held at the Sulpician Library, L'Ecole Polytechnique, with Vice President Bennett in the chair. This session was devoted exclusively to the address of Dr. Leo Pariseau on "The Contribution of the Electrical Engineer to Medical Science." This was illustrated.

The annual dinner was held at the Mount Royal Hotel with President Rees presiding. Mr. O. W. Eshbach presented the report of the Committee on Lamme Award concluding his report with the remark that "In recommending this recipient we not only honor him but we honor ourselves for none of the 7,000 eligible candidates has contributed more to the advancement of engineering education than has Charles Felton Scott, Professor of Electrical Engineering, Yale University."

Deans Sackett and Leland escorted the recipient to the chair where President Rees presented the third Lamme gold medal to Dr. Scott, saying, "Dr. Scott, your ability, capacity, and constructive imagination have contributed greatly in many fields of human endeavor, but out of our hearts we consider you greatest in the contributions which you have made for the promotion of engineering education. In the name of the Society and of each of the more than 2,000 members, and by the authority vested in me as President, it is a privilege and a high honor to present to you the Lamme medal."

Professor Scott accepted the medal with a few well-chosen words.

Edward R. Weidlein, Director of the Mellon Institute of Industrial Research, University of Pittsburgh, spoke on "Industrial Research Methods and Workers," and Walter W. Colpitts, Consulting Engineer and graduate of McGill University, spoke on "The Engineer and Finance."

SATURDAY, JUNE 28, 1930

The fourth session was held at Moyse Hall, Arts Building, McGill University, and President Rees called the meeting to order at ten o'clock.

The report of the Treasurer, which had been audited, was read by the Secretary in Mr. Wiley's absence from the country. The report was accepted and ordered printed in the JOURNAL.

The report of the Secretary was read and ordered printed in the JOURNAL.

H. P. Hammond, Director of Summer Schools for Engineering Teachers, reported on the Drawing Session which had just been concluded at Carnegie Institute of Technology and on the Civil Engineering Session which was to be held at Yale University beginning the next week. He also presented tentative plans for schools for 1931.

Charles F. Scott, Chairman, reported for the Board of Investigation and Coördination, stating that the first volume of the final report was now in the hands of the members and that the second volume would be forthcoming shortly.

D. B. Prentice, Lafayette College, read his paper "Measuring

the Product of Engineering Schools," and S. D. Sarason, Syracuse University, presented his paper, "Aerial Photo Surveying and Mapping." Both papers were accompanied by lantern slides.

Augustin Frigon, Director-General of Technical Education for the Province of Quebec, and Robert H. Spahr, General Motors Institute of Technology, discussed technical institute education in Canada and in the United States.

The Committee on Resolutions presented the following report:

"As the thirty-eighth annual meeting of the Society for the Promotion of Engineering Education approaches its closing session in Montreal, the members in attendance recognize anew the important part which these regular gatherings play in fostering the ideals and in advancing the purposes of the Society.

"Mindful of the values received and of the inspiration to further endeavor accorded by these conferences, and keenly cognizant of the preeminent contributions of the host institutions which have made this meeting so enjoyable and so successful, the Society hereby records in all too inadequate words its sincere thanks and appreciation to all who have so cordially and untiringly contributed to the comfort and entertainment of the members and their families.

"To the Chancellor, Vice-Chancellor, and Governors of McGill University, for their generous placing of meeting facilities at the disposal of the Society; for the hospitable and inspiring welcome; and for the delightful entertainment afforded by the Garden Party; to the Principal and others of the Governing Board of L'Ecole Polytechnique, for the gracious tender of their halls; for the charming welcome; and for the bounteous luncheon to Council and guests; to the members of the several local committees, and especially to the Ladies' Entertainment Committee, for the excellently planned and carefully administered activities which so abundantly contributed to the comfort and pleasure of every member; to the guest speakers whose addresses furnished such a wealth of inspiration and encouragement; and to all those industrial firms which so kindly placed their plants at the disposal of members for inspection;

"The Society feels that this, its second meeting in Canada, has been one of its most successful and enjoyable, and looks forward with the happiest anticipations to some future return to enjoy again the many courtesies and bountiful hospitality of its Canadian friends."

The fifth session was held in Moyse Hall, Arts Building, McGill University. Vice President Hitchcock called the meeting to order at three o'clock. This meeting was devoted to the subject of "Research" with the following speakers: F. E. Lathe could not be present and was represented by Dr. Parkins who is in charge of Aeronautical Division of the National Research Council of Canada; R. A. Seaton, Kansas State Agricultural College; H. H. Higbie, University of Michigan; C. F. Harding, Purdue University; Thornton C. Fry read the paper of John Mills, Bell Telephone Laboratories, Inc., who was unable to be present.

T. M. Focke, Chairman, Committee on Coördination of Preparatory and Engineering Education, presented the report of that committee.

The Secretary presented the report of the Committee on Graduating Personnel.

The meeting adjourned at five o'clock to meet at Purdue University, Lafayette, Ind., in June, 1931.

MINUTES OF THE COUNCIL MEETINGS

The following are the minutes of the Council meetings held at Montreal, June 25–28, 1930.

Present: President R. I. Rees, Vice-Presidents, E. A. Hitchcock, Edward Bennett, Secretary F. L. Bishop, L. E. Akeley, H. S. Boardman, J. M. Bryant, Paul Cloke, C. S. Coler, I. C. Crawford, R. C. Disque, W. E. Farnham, T. M. Focke, R. C. H. Heck, H. H. Higbie, H. P. Hammond, C. F. Harding, W. C. Huntington, S. S. Edmands, D. C. Jackson, A. C. Lanier, O. M. Leland, J. E. McDaniel, C. M. McKergow, G. B. Pegram, A. A. Potter, D. B. Prentice, H. S. Rogers, N. C. Riggs, R. L. Sackett, C. F. Scott, R. A. Seaton, A. N. Talbot, W. H. Timbie, F. E. Turneaure (35).

The report of the Secretary was read and ordered printed in the JOURNAL OF ENGINEERING EDUCATION.

The request of Lehigh University that this Society send them a list of representatives to whom invitations to the dedication of the James Ward Packard Laboratory of Mechanical and Electrical Engineering next October, may be sent—the Secretary instructed to send them the names of the past officers and members of committees.

Invitations for the 1931 meeting were received from Purdue University and Stanford University. Lafayette College extended an invitation for 1932 which is their centennial year. The invitation of Purdue University was accepted for the 1931 meeting of the Society.

The Council voted that a committee be appointed to consider the advisability and the practicability of classifying engineering colleges and that this committee report to the Council in 1931.

The Director of the Summer School for Engineering Teachers, H. P. Hammond, reported on the School on mechanical engineering at Purdue in 1929, the Drawing session at the Carnegie Institute of Technology and the Civil Engineering session at Yale University in 1930. For 1931 we have an invitation from the American Institute of Chemical Engineering, also from the University of Michigan, to hold a session on chemical engineering. The Council approved the holding of the 1931 school on chemical engineering at the University of Michigan contingent on securing the necessary funds.

The Mathematical Association of America and the American Mathematical Society approve the holding of a session of teachers of mathematics to engineering students if held at the time and place

of the meeting of the two societies in the late summer of 1931 at Minneapolis. The Council approved the holding of this session at the discretion of the Board of Investigation and Coördination and contingent upon securing the necessary funds.

Director Hammond also reported that the number of colleges, which send representatives at the expense of the institution, are increasing.

Council expressed its appreciation of Director Hammond's splendid manner in conducting and organizing summer schools.

C. S. Coler, Chairman of the Committee on the Lamme Award, made a motion, which was seconded and carried, that the Committee one year from now make a definite recommendation concerning the publication of a booklet containing pictures together with brief descriptions of achievements of recipients of the award.

With regard to the suggestion that "members having performed a signal service to the Society should be designated Fellows, and others members" the Council felt that the Society has, from the beginning, been democratic and that no distinction should be made among the members.

The Council instructed the Secretary to correspond with the secretary of the Association of Junior Colleges suggesting closer coöperation and ascertain if a committee of each might consider some of the common problems of the junior and of the engineering colleges. Motion that a committee on junior colleges be appointed to consider the relation of junior colleges in engineering and engineering schools and report to the Council in 1931.

Council authorized the appointment of a committee of personnel directors and college professors to consider existing practices and to determine whether they best serve the three interests concerned and possibly some other plan of recruiting, and to report at the 1931 meeting.

Council appointed A. N. Talbot, D. B. Prentice and Edward Bennett as a committee to study the question of this Society making nominations for the Popular Science Monthly $10,000 annual award for 1930. At a later meeting, the Committee reported that it was their feeling that if nominations were to be made from this Society that they should be made for work in education and it was not ready to propose any nomination at this time. For this reason, the Committee reported that no nomination should be made for 1930.

H. H. Higbie, University of Michigan, explained the purpose of the Stump Speaker's Society—membership open only to students in colleges of engineering and architecture and schools of technology.

An invitation was extended to the Society to participate in the International Road Congress to be held in the United States in October, 1930.

The President was authorized to appoint a committee to consider the communication from G. T. Seabury, concerning the Recommended Uniform Registration Law for Professional Engineers and Land Surveyors and to report back to the Council.

The report of the Treasurer was read and ordered printed in the JOURNAL OF ENGINEERING EDUCATION.

It is the sense of the Council that the Society for the Promotion of Engineering Education should be a member of the American Engineering Council but we are not yet confident of our financial ability to join.

Council voted that we recommend to the Society that the name of the Society for the Promotion of Engineering Education be changed to Engineering Education Society.

The Committee on Instruction in Industrial Relations was continued for another year.

Council authorized the appointment of a committee to consider engineering degrees as relating to the four founder engineering societies.

Motion that a survey of vocational guidance practices prior to enrollment and during the first year in engineering schools; study of personnel methods in use in engineering schools; and a survey of methods and procedures of administration for improving educational and instructional standards be referred to the existing committee with the urgent recommendation of the Council that they be studied intensively during the coming year and reports be presented at the next annual meeting.

The Executive Committee was instructed to coöperate with the Office of Education, Department of Interior, to obtain such information as we desire and to see that in the publications of that Department we are properly represented in number of pages and type of material.

The Secretary was instructed to express our appreciation to the Office of Education for the hearty coöperation we have been receiving.

The Chairman of the Board of Investigation and Coördination, C. F. Scott, reported that the first volume of the final report was now in the hands of every member who had paid his dues, and that the second volume would be issued shortly.

Council voted that this Society enter wholeheartedly into participation in the World's Fair in Chicago in 1933 and the Executive Committee is given power to formulate plans and to coöperate with other agencies. The retiring president, R. I. Rees, is to be a member of this Committee. The Executive Committee may add other members to the committee at its own discretion.

Council approved the following budget for 1930–31:

RECEIPTS

Individual Dues	$ 9,500.00
Institutional Dues	1,785.00
Back Dues	500.00
Advertising	2,000.00
Sale of Publications	350.00
Estimated Receipts	$14,135.00

DISBURSEMENTS

A. 1930 Meeting	$ 600.00	
B. Journal, Proceedings, Year Book	7,500.00	
C. Committee Expenses	150.00	
D. Secretary's Honorarium	1,200.00	
E. Clerical Assistance	3,300.00	
F. Sundry Printing	300.00	
G. Postage	300.00	
H. Telephone and Telegraph	50.00	
I. Supplies	200.00	
J. Traveling Expenses	500.00	14,100.00
Estimated Surplus		$ 35.00

Council approved the election of the following applicants:

Ananthanarayanan, Sivaramakrishna, Principal, School of Civil Engineering, 10, Pandadiaml, Andar Street, Teppakulam Post., Trichinopoly, India. F. L. Bishop, Nell McKenry.

Baldwin, Leo S., Assistant Professor of Drawing, University of Wisconsin, Madison, Wis. H. D. Orth, C. V. Mann.

Boyer, Aurelien, Principal, Ecole Polytechnique de Montreal, Montreal, Canada. A. Frigon, T. J. Lafreniere.

Bukovsky, Paul N., Assistant Professor of Mechanism and Engineering Drawing, University of Michigan, Ann Arbor, Mich. F. R. Finch, G. A. Morley.

Circe, Armand, Professor of Strength of Materials, Ecole Polytechnique de Montreal, Montreal, Canada. A. Frigon, O. Lefebvre.

Doty, L. Donald, Instructor in General Engineering Drawing, University of Illinois, Urbana, Ill. H. H. Jordan, G. J. Hood.

Dunham, Earl M., Instructor in Engineering Drawing and Descriptive Geometry, University of Maine, Orno, Me. F. G. Higbee, Alva Mitchell.

Frey, George J., Head, Department of Mechanical Engineering, Ohio Mechanics Institute, Cincinnati, Ohio. C. L. Svensen, T. E. French.

Huffmon, Raymond L., Instructor in Engineering, Loyola University, Glendale, Calif. D. M. Wilson, G. H. Dunstan.

Kennard, Harold J., Assistant Professor of Graphics, Lafayette College, Easton, Pa. H. P. Hammond, F. G. Higbee.

Kepner, Harold R., Assistant Professor of Civil Engineering, Utah Agricultural College, Logan, Utah. H. M. McCully, T. E. French.

Landreau, Georges L., Professor of Engineering Drawing, Ecole Polytechnique de Montreal, Montreal, Canada. A. Frigon, O. Lefebvre.

Leet, Horace W., Professor of Machine Design and Mechanical Drawing, University of Rochester, Rochester, N. Y. H. M. McCully, T. E. French.

Lichty, Lester C., Associate Professor of Mechanical Engineering, Yale University, New Haven, Conn. S. W. Dudley, W. J. Wohlenberg.

Miller, John B., Instructor in Electrical Engineering, Bucknell University, Lewisburg, Pa. F. E. Burpee, F. L. Bishop.

Nettleton, Ernest M., Assistant Professor of Drawing and Descriptive Geometry, Carnegie Institute of Technology, Pittsburgh, Pa. H. M. McCully, W. E. Mott.

Payrow, Harry G., Assistant Professor of Civil Engineering, Lehigh University, Bethlehem, Pa. J. C. Tracy, H. P. Hammond.

Shaw, Robert P., Secretary, National Research Council Advisory Committee, Chicago World's Fair, 40 West 40th Street, New York City. R. I. Rees, A. A. Potter.

Singer, Ferdinand L., Instructor in Engineering, New York University, New York City. H. C. Hesse, B. M. Green.

Slantz, Fred W., Professor of Graphics, Lafayette College, Easton, Pa. H. P. Hammond, F. G. Higbee.

Smith, G. Wallace, Associate Professor of Engineering, University of North Carolina, Chapel Hill, N. C. F. G. Higbee, W. G. Smith.

Townsend, Clarence E. Professor of Engineering Drawing and Descriptive Geometry, Cornell University, Ithaca, N. Y. Thos. E. French, H. P. Hammond.

Wendling, Andre V., Professor of Physics, Ecole Polytechnique de Montreal, Montreal, Canada. A. Frigon, O. Lefebvre.

Whenman, John H., Instructor in Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. F. G. Higbee, W. G. Smith.

Wilson, Earl R., Instructor in Engineering Drawing, University of Akron, Akron, Ohio. F. G. Higbee, Fred S. Griffin.

Respectfully submitted,

F. L. Bishop,
Secretary.

REPORT OF SECRETARY, F. L. BISHOP, 1929–30

Membership

No membership committee was appointed during the current year. The campaign for members was conducted in the Secretary's office, very largely by the assistant secretary. We have added 218 new members to the rolls since our last meeting, 3 by reinstatement, 203 by election and 12 applications pending. We have lost 13 members by death (list attached) and 92 have resigned or have been dropped for non-payment of dues. We have, therefore, an increase in membership of 114 over June 1929. We now have 2211 individual and 119 institutional members, or a total of 2330. However, there are 81 who will have to be dropped at the close of this convention for non-payment of dues, so that the actual membership will be 2249.

It is interesting to note in this connection that there are 22 charter members (list attached) still on the rolls of the Society, seven of whom are past presidents. We have 20 members (list attached) who are designated as Life Members.

Dues

The dues for all members are payable in advance at the time of the annual convention. This past year, your Secretary sent out two bills for dues. A third notice sent out was a red card which read "I don't like to send out bills any better than you like to receive them, but the duties of my office require that I send them out until you pay. . . ." Some of the comments on this notice are "Such a notice is a disgrace to the Society and does more harm than good." "My humblest apologies." A fourth notice was sent out of May 13 advising those who had not paid that they would not receive a copy of the final report of the investigation. As a result of these four notices, $10,579.00 was collected in current dues and $1,287.14 in back dues. At this writing, June 18, 1930, there are 129 members who owe 1929–30 dues, and 60 who owe 1928–29 and 1929–30 dues. In addition to these there are 81 members who owe more than $10 and these will be dropped for non-payment of dues at the close of this meeting. (List of delinquents attached to this report.)

Finances

The report of the Treasurer will show that the finances of the Society are in a satisfactory condition. (Auditor's report attached.)

Investigation of Engineering Education

Results: It was felt by many that it was very important to determine to what extent the results of the investigation which has been carried on by this Society had been effective in making changes in curricula, etc., of our engineering colleges. The President of the Society secured the coöperation of the Office of Education and questionnaires were sent out to all the engineering colleges. Replies have been received from 119. These results have been tabulated and will be presented at the first session of this convention.

Final Report: The first volume of the final report of the Board of Investigation and Coördination was completed in the office of the Secretary during the current year and is now in the hands of all members who have paid their dues. The editorial work connected with this added very materially to the burdens of the Secretary's office during the year.

Comparison of investigation of engineering education and of medicine:

The two professions, Engineering and Medicine, are more closely connected with the progress of the world than any other two professions—the first in employing the materials and forces of nature, and the latter in keeping men fit to work with these materials and forces.

What should be more fitting than, almost simultaneously, committees should be formed "to carry on a five-year investigation of medical education" and of "engineering education." In 1923, this Society appointed a committee and funds were secured to carry on such an investigation, and in 1925, a commission was appointed under the auspices of the Association of American Medical Colleges, "with funds donated from several agencies interested in the subject." The Society has issued sixteen pamphlets covering the results of the investigation of engineering education, and the Commission has issued three annual reports on medical education. Dr. N. P. Colwell, Secretary of the Council on Medical Education and Hospitals of the American Medical Association, quotes the third report in his article, "Medical Education, 1926–1928," which appears in Bulletin, 1929, No. 10, Department of the Interior, Bureau of Education.

A comparison of the report on medical education with those on engineering education shows many things in common:

1. (Medical) "The first duty of a medical School is to provide its students with a thorough grounding essential for every practitioner of the healing art."

"Engineering curricula aim to provide a thorough grounding in the principles of science and the methods of engineering, together

with elements of liberal culture intended to enrich the personal life of the student and fit him for a worthy place in human society."

2. (Medical) "Experts in graduate medical education now agree that an interneship to round out the student's undergraduate medical education, should be completed before the young graduate enters on his preparation for any specialty."

"The undue emphasis in medical teaching which is laid on the separate organs and systems which make up the human body rather than considering man as a complete living human being. This is resulting in a marked and dangerous trend toward specialization."

(Engineering) We believe the proper time for specialization is after the undergraduate course, and that in a majority of cases specialization must accompany active experience rather than take the form of a further discipline in college."

3. (Medical) The commission calls particular attention to the advisability of more electives in the curriculum.

(Engineering) General indications point to increasing latitude of election in recent years, although engineering curricula in general remain largely on a prescribed basis."

4. (Medical) The urgent problem is to ascertain how the benefits of modern medical care can be brought within the reach, both physically and financially, of the greatest possible proportion of the people."

(Engineering) The next phase of the effort of the Society should be to awaken the public to the importance of engineering education and research as factors in individual and social well-being."

The Commission calls attention to "The tendency to prolong unnecessarily the student's period of preliminary and professional education." Eight medical schools, out of the seventy-four recognized by the American Medical Association, have either adopted, or will adopt in 1930, the quarter system. Under the so-called quarter system a student can complete the four required college years of medical education of eight or nine months in three calendar years. Any three consecutive quarters of completed work would count as a "college year." The avowed adoption of this plan by the new school of medicine at Duke University has given fresh impetus to the movement and shows that the plan is feasible, even in the warmer climate of the Southern States. The Commission calls particular attention to "such shortening of existing courses as may be possible and the saving of time by the use of over-long summer vacations is strongly urged."

American Engineering Council

Negotiations have been carried on by your Executive Committee with the American Engineering Council looking to the affiliation

of this Society with that organization. A definite proposition will be presented to you at this meeting for action. The Secretary is of the opinion that the Society can be of distinct service to that organization and at the same time secure benefits for all engineering education.

The question of affiliation with the American Engineering Council is largely one of finances. It should receive careful consideration of the Council at this time.

Employment Service

The employment service which the Secretary's office has always carried on has been placed on a more formal basis. Circular letters were sent to all deans asking for information concerning vacancies and a statement was published in the Journal of Engineering Education stating that such service was available to all members. The Secretary's office in this way secured information of over thirty vacancies and received applications for positions from about twice that number.

Who's Who in the S. P. E. E.

At the last convention the Council authorized the preparation of a card index of Who's Who in the Society for the Promotion of Engineering Education. This has been prepared through the sending out of cards to all members. 955, or 43¼ per cent, returned these cards to this office. Of course, during the coming year we shall endeavor to make this complete.

Summer School for Teachers of Engineering

The establishment by this Society of summer schools for teachers of engineering has proved to be one of the most successful educational experiments of the present generation. Last year a session on mechanical engineering was held at Purdue. This year a session has already been held in drawing with an attendance of 100 at the Carnegie Institute of Technology in Pittsburgh, and a second one in civil engineering will start immediately after this convention at Yale. The Director of the Summer School, Professor H. P. Hammond, will report to you more in detail concerning these. An interesting feature of this work has been the alumni meetings of these schools which are held at the time of the annual convention.

Work of Committees

The work of your committees during the past year has been carried on in an energetic manner. It is, of course, not feasible to have all committees of the Society which are studying educational

problems report each year. However, this year some notable reports will be made—such as the Committee on Industrial Relations, R. L. Sackett, Chairman.

Conferences

A feature of the annual conventions which is becoming more important each year is that of the conferences held preceding the first session. This year you will note on the program nine conferences each of which has provided an interesting program for those who are especially interested in a particular feature of engineering education.

Year Book

The year book was published as early as possible. We attempted to have it issued in November but it was January before it was mailed to members. Early publication of the year book depends upon the effectiveness of the membership in returning their information cards.

Journal of Engineering Education

When the Bulletin of the Society now the Journal of Engineering Education was established in 1910, the Treasurer had the following remarks to make concerning it:

> "The Bulletin publication involves an expenditure of considerably over $150 per month, but with the coöperation of advertisers and members we shall be able to carry this if dues are paid promptly."

The Journal of Engineering Education now costs us an average of $800 per issue of which the advertisers pay $225. The statement of the treasurer in 1910 still holds good. We can pay our bills if the dues are paid promptly.

Beginning with the September Journal we are to make the margins on the pages of the Journal less, consequently, include more words to the page and thus reduce somewhat the cost of printing. During the past year we have secured estimates on the cost of publishing the Journal from a number of other concerns. No one has been able to quote us a price as low as the Lancaster Press, Inc.

In order that the work of the Society may make distinct progress during the coming year, certain definite actions are necessary for the Council. I recommend that the information which has been secured during the present year through the United States Office of Education be continued and the Society formally thank them for their coöperation, and further that a committee be appointed with General R. I. Rees as chairman to continue this work.

You will note invitations from two institutions for the 1931 meeting. I think these invitations should receive this year especially careful consideration and that perhaps we should fix the convention not only for 1931 but for 1932. It is certainly desirable that we should have, in the very near future, a convention on the Pacific Coast in order that we may create more interest in the work of the Society among engineering teachers and others in that section of the country. The Society has never held a convention farther west than Boulder, Colo. We know that if we accept the invitation to meet at Purdue we shall have one of the most successful and largest conventions in the history of the Society. Its central location and the number of large engineering schools within a relatively short distance lead us to consider this matter very seriously.

In this same connection there will be presented to you a report of the special committee appointed by President Rees to consider what this Society should do to celebrate its fortieth anniversary at the Worlds Fair in Chicago in 1933. You are all familiar with the fact that the Society started as Section E at the Worlds Fair in Chicago in 1893.

Your Secretary recommends that each member invite personally at least two of his colleagues who are eligible to join the Society. If each member did this the scope of the Society would be broadened and we would not need a membership committee for 1930–31.

REPORT OF THE TREASURER, W. O. WILEY *

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

STATEMENT OF CASH ACCOUNT

June 17, 1930

BALANCE ON HAND—JUNE 15, 1929		$ 6,689.80
RECEIPTS:		
Current Dues	$10,579.00	
Back Dues	1,282.14	
Dues in Advance	132.00	
Sales of Publications	2,281.38	
Advertising	2,286.72	
Interest on Daily Bank Balances	136.56	16,697.80
Total		$23,387.60
DISBURSEMENTS:		
Cost of Publications	$10,313.48	
Cost of Proceedings	456.90	
Honorarium for Secretary	1,000.00	
Clerical Assistance—Secretary's Office	3,000.00	
Traveling Expenses—Secretary's Office	446.01	
Printing, Postage and Office Supplies	996.06	
Committee Expenses	56.16	
Expenses—Columbus, Ohio Meeting—1929	572.48	
Expenses—Montreal, Canada Meeting—1930	377.87	
Dues—American Council on Education	100.00	
For Institutional Division, Personnel Problems	77.04	
Lamme Medal Fund Expenses (To be repaid)	210.35	17,606.35
BALANCE ON HAND—JUNE 17, 1930		$ 5,781.25

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

INCOME AND EXPENSE ACCOUNT

At June 17, 1930, for the Year Ending June 30, 1930

EXPENSE

Cost of Bulletins	$ 8,737.17
Cost of Proceedings	456.90
Expenses—Columbus, Ohio Meeting	636.17
Honorarium for Secretary	1,000.00
Clerical Assistance—Secretary's Office	3,000.00
Printing, Postage and Office Supplies	996.06
Traveling Expenses—Secretary's Office	446.01
Committee Expenses	56.16
Dues—American Council on Education	100.00
	$15,428.47
Surplus for the year	999.73
	$16,428.20

* The accounts of the Treasurer are audited and the report of the Auditor is presented as the report of the Treasurer.

Income

Current Dues	$11,204.00
Back Dues	782.14
Sales of Publications	2,281.38
Advertising	2,024.12
Interest on Daily Bank Balances	136.56
	$16,428.20

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

Balance Sheet

June 30, 1930

Assets

Cash:		
Current Fund	$5,781.25	
Petty Cash Fund	300.00	
Life Membership Fund	617.40	
Benj. G. Lamme Fund	537.70	$ 7,236.35
Securities:		
Benj. G. Lamme Fund		5,000.00
Prepaid Expenses—Montreal Meeting 1930		377.87
Inventory		470.50
Accounts Receivable:		
Current Dues	$ 500.00	
Advertising	585.00	
Lamme Medal Fund	1,235.63	2,320.63
Furniture and Office Equipment		183.35
		$15,588.70

Liabilities

Life Membership Fund		$ 617.40
Benj. G. Lamme Fund		5,537.70
Institutional Division: Personnel Problems Fund		827.72
Prepaid Membership Dues		132.00
Accounts Payable (Estimated)		1,500.00
Surplus Account:		
Balance—July 1, 1929	$5,974.15	
Surplus for this year	999.73	6,973.88
		$15,588.70

REPORT OF S. P. E. E. SUMMER SCHOOL FOR TEACHERS OF ENGINEERING

BY H. P. HAMMOND, *Director*

I shall make this report very brief. It is proper I think that there should be an accounting made each year to the general meeting of the Society concerning the Summer School.

With the inclusion of the coming session at Yale, there will now have been seven sessions of the summer school devoted to six divissions of the curriculum. We shall have had a total attendance at the end of this year of 459 regular members of the group and nearly 200 members of the staff—a total of 650 teachers who have been brought intimately into contact with the summer school work. This is a very fair fraction of all of the teachers of engineering in the country, roughly, 10 per cent, and aside from a few duplications of men who have attended more than a single session, I think it is an index of the fact that whatever value the summer school may have is being felt in the institutions throughout the country.

The attendance at these sessions is extremely representative. As an illustration, the drawing session just concluded at Pittsburgh, included men from 31 different states and two Provinces of Canada. They represented 57 different institutions. The attendance was also very evenly distributed by teaching ranks. At each of the sessions we customarily have two or three deans. We have 20 odd full professors, 25 or 30 associate and assistant professors, and an equal number of instructors. So the range of teaching ages and experience is from the oldest and most experienced teachers in our colleges to the young men who have just graduated and who are to take up their teaching work in the fall.

The session about to commence next week at New Haven on civil engineering is perhaps our most elaborate summer school, our most ambitious effort to date. It will be divided into the three principal divisions of civil engineering instruction; structural engineering, sanitary and hydraulic engineering, and transportation engineering, which we are calling railway and highway engineering. There is to be a staff of over fifty men in all, and it will be attended by about 90 teachers.

The drawing sessions, by the way, set the record for attendance with 102.

I might go back just a moment to say that when the summer school was started we had the idea of limiting it to a relatively

small number so that the discussions would be intimate and we could have a small group, all of whom would know one another by the time the session was over. We set a limit of attendance for the first year of 30 at each session. We could not adhere to this and even before the first session convened we had to raise that limit to 40. Now we have simply had to give up the idea of any limitation of attendance. The pressure on us to admit the various men is too great, and it seems unwise to make any discrimination. The result has been that the sessions have increased in number as we go from year to year, from 40 two years ago to 102 at the drawing session this year.

I would like to take this opportunity, Mr. President, to say this: that the summer school has proved the value of coöperative effort in the Society just as its general investigation has. Each of the sessions has been made successful, I believe, by the endeavors of a large group of people, the local directors and secretary, the full-time staff, and the lecturers who are called in from time to time on special subjects. It has been made successful, furthermore, by the splendid spirit of the men who attend. No one can describe it. They would have to be at one of the sessions to understand what I mean. Many of you have attended one of the sessions and perhaps what I am saying is not necessary for you, but I wish the others might at least visit those sessions for a day or two and see something of the vigor with which our groups attack their problems of teaching.

I should perhaps speak of the tentative plans which have been made for next year. When we first began the summer school the initiative in the organization of the sessions came from the Board. It has now passed to the Society membership, and each year we are petitioned to hold sessions on one or more subjects. For next year we have had two such petitions, one originating with the American Institute of Chemical Engineers, that has by action of its governing body requested this Society to hold a session for teachers of chemical engineering. That petition was received sympathetically and approved upon the making of the necessary arrangements. Those arrangements have been started by opening negotiations with the University of Michigan, and through the President and Dean Sadler, the Society has received an invitation to hold the session on chemical engineering at Ann Arbor in the summer of 1931. The University has, incidentally, offered very generous support, financially and otherwise, for that session. I cannot report the final conclusions of the arrangements for the session, however, since we still need to secure some of the funds necessary.

The second petitions were received from the two national mathematical organizations, the American Mathematical Society and the Mathematical Association of America, indicating approval of the

holding of summer sessions for teachers of mathematics by this Society. Again that has been submitted to the Council and approved, contingent upon making the necessary arrangements. I have been in conversation with Dean Leland, of the University of Minnesota during this meeting, since the two societies request us to hold the session at the time and place of their annual convention, which is to be in Minneapolis in 1931. I am hopeful that that session also will come about.

By the end of next year then, we shall have held sessions on eight different subjects of the curriculum, and we shall have pretty nearly reached the place where we can start over again in the summer of 1932 with our original subjects, although there are a number yet to be covered.

Discussion

President Rees: I can certainly testify to one of Professor Hammond's first statements, and that is as to the fine spirit which imbues every one of these summer schools, and the enthusiastic interest which is shown by both staff and student personnel.

Secretary Bishop: Mr. President, I think that this report should be discussed a little in this way: We ought to look forward quite a distant time in the future in regard to the next type of summer schools. I think this would be a good opportunity for an expression from the floor as to what summer schools might be held in the future.

R. C. H. Heck: Having a cycle of about six or seven years it would be a good plan to go around the circle again. There are new men coming in each year and that would make it worth while.

Member: I attended the school at Purdue. I don't see how it could be improved on. Professor Hammond has done a wonderful job. He has so planned the schools that they are almost perfect.

Mr. Hammond: I should like to add to my statement about the summer schools. We should acknowledge very cordially the coöperation that has been given this Society by the National Engineering Societies, the American Society of Mechanical Engineers, the American Society of Civil Engineers, and now the American Institute of Chemical Engineers. It is proper that that should be a matter of record in the proceedings of this meeting.

President Rees: I think through the activity which Professor Hammond is directing, we are coming to a more cordial, sympathetic and active coöperative condition with all of the engineering societies.

REPORT OF DIVISION OF MECHANICS

At this Annual Meeting of S. P. E. E. your newly formed Division of Mechanics makes its first bow. For several years it had been in the minds of some of us that the number of members of the Society interested in the teaching of Mechanics was sufficiently large to warrant the formation of a Division. Last summer your Council acted favorably upon our request, and the new Division took over the work of your former Committee No. 27.

Last June, following the Annual Meeting at Columbus, Ohio, a four-day Conference on the teaching of Mechanics was held, which was attended by 38 men representing 24 different institutions. The discussions in general were very informal, and everyone present took an active part. Many points of view were stated, which after discussion did not prove to be so divergent as they had at first appeared. A brief report of the Conference was published in the Journal of Engineering Education for December, 1929.

At one of the sessions last year, the question was raised as to the percentage of students entering Mechanics who received a condition or failing grade. No one present had definite figures at hand, but estimates from memory varied from 5 per cent to 50 per cent. It was felt that some definite data on the matter would be interesting, and that results over a period of several years should be obtained. We have collected data from five schools, (with more promised), covering the five-year period from 1924 to 1929, and find that in these schools instead of the wide variation from 5 to 50 per cent, there is the much more reasonable variation from 16 to 38 per cent, with an average of 24 per cent. Even this variation would probably be reduced if exactly the same methods of computing percentages were used in all cases. For instance, students who registered but dropped the subject within a short time are counted by some as having failed, but by others are not counted at all.

We judge from these results, and also from the quality of preparation of students who transfer from other schools with partial credit, that the standard of achievement required in the different schools is very much the same.

An attempt was made also to obtain some data on the correlation of the individual student's grades in mathematics and physics with his later grades in mechanics, but on account of the difference in courses and in methods of grading at the different schools, no comparison of results was considered feasible. A paper written by Professor W. B. Sanders of Purdue and presented at our Confer-

ence here Thursday morning gives the results at Purdue. Valuable use has been made of this study at Purdue, and decisions on all cases involving admission to Mechanics without the full prerequisites are always based upon the student's previous record. The chief difficulty in administration consists in persuading each student who is refused admittance to the course that his case is not one of the glowing exceptions to the rule.

Respectfully submitted,

G. P. BOOMSLITER,
J. E. BOYD,
E. R. MAURER,
C. E. PAUL,
E. W. RETTGER,
N. C. RIGGS,
LEROY TUCKER,
S. M. WOODWARD,
A. P. POORMAN, *Chairman.*

THE T-SQUARE PAGE

By FREDERIC G. HIGBEE
University of Iowa, Editor

As an outgrowth of the conferences on engineering drawing held at the annual meetings of the Society for the Promotion of Engineering Education at Cornell University in 1923; at the University of Colorado in 1924; at the University of Iowa in 1926; and at the University of Maine in 1927; the division of engineering drawing was organized and authorized by the Council at the Chapel Hill meeting of the Society in 1928. At all these meetings, teachers of drawing and descriptive geometry felt that many of the problems which were presented for discussion could be more fairly digested and put into form by committees assigned to the task of studying the many points raised in the conferences. Consequently, at the Chapel Hill meeting the organization of the division of drawing was perfected and an executive committee was appointed to set up an organization which would function along the lines indicated by previous discussions.

Immediately following the Chapel Hill meeting a committee on engineering drawing with Professor H. M. McCully of the Carnegie Institute of Technology of Pittsburgh as chairman; a committee on descriptive geometry with Professor William G. Smith of Northwestern as chairman; a committee on research with Professor C. V. Mann of the Missouri School of Mines as chairman; and a committee on summer session with Professor F. G. Higbee of the State University of Iowa as chairman were appointed. The executive committee was composed of seven members with Professor Thomas E. French of the Ohio State University as chairman and Professor R. P. Hoelscher of the University of Illinois as secretary.

The reports of these four committees formed the basis of the first meeting of the division of engineering drawing at the Columbus meeting in 1929. Not only the reports themselves but the general discussion which followed justified the belief that engineering drawing teachers would have a common interest which when properly directed would result in productive and interesting work.

Later issues of the JOURNAL will contain abstracts of the reports submitted by these committees and an outline of research projects now begun. As a direct result of the report of the committee on summer session, with its accompanying recommendation to the Council of the Society, the request of the engineering drawing

division was granted and a summer school for engineering drawing teachers was put upon the program of the Society for the summer of 1930. One of the important by-products of the 1930 summer school for drawing teachers was the general agreement of those attending that a page in the JOURNAL devoted to the interests of the engineering drawing teachers would be desirable. In accordance with this expressed opinion a recommendation from the summer school was presented to the engineering drawing division at the Montreal convention in 1930 and the division unanimously agreed to request the editor of the JOURNAL for a page. This page, it was agreed, was to be known as the "T-Square Page."

In accordance with this action the editor has reserved a page in this JOURNAL which hereafter will be known as the "T-Square Page." In the course of time it is hoped a suitable design may be printed at the top of the page which will be indicative of the nature of the page and the interest it serves. At the meeting of the executive committee of the engineering drawing division following the Montreal meeting, Professor Frederic G. Higbee of the University of Iowa was appointed editor and from this date each issue of the JOURNAL will contain "The T-Square Page" devoted to the interests of teachers of engineering drawing, descriptive geometry and related subjects.

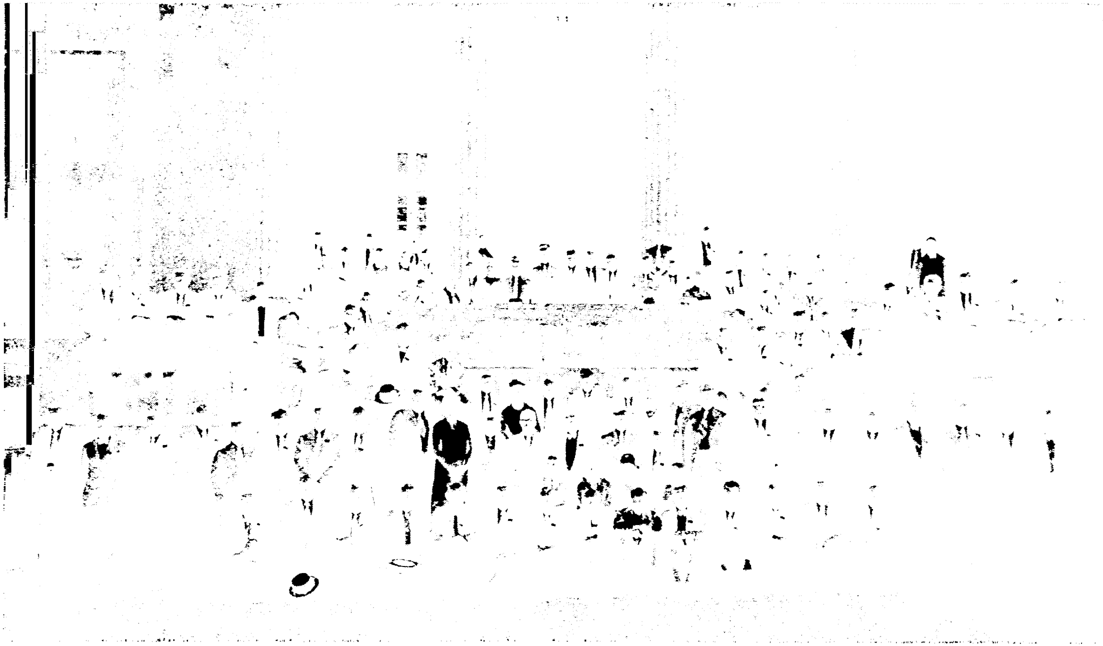
THE 1930 SESSIONS OF THE S. P. E. E. SUMMER SCHOOL FOR ENGINEERING TEACHERS

By H. P. HAMMOND, *Director*

The two sessions of the Society's Summer School, of 1930, were the best attended and in many respects the most successful thus far held. Eighty-eight teachers enrolled in the civil engineering session, held at Yale University from July 1 to 23 inclusive. The staff numbered fifty-two. The session on engineering drawing and descriptive geometry, held at the Carnegie Institute of Technology from June 12 to 21 inclusive, was attended by ninety-nine teachers, with a staff of twenty members.

Both sessions were remarkable for the widely representative nature of the attendance. The members of the civil engineering session came from twenty-seven states, two provinces of Canada and one foreign country. Sixty colleges were represented. At the drawing session thirty-three states and provinces of Canada and fifty-seven different institutions were represented. The attendance was also remarkably representative of the various teaching ranks, the two sessions taken together including three deans, fifty-eight professors, thirty-six associate professors, fifty-three assistant professors, thirty-six instructors and one assistant, these numbers being nearly proportional to the total numbers of teachers of these ranks in engineering colleges. Since the establishment of the summer school in 1927 there has been a shift in the age and rank of those attending from the younger to the older men, the sessions of 1930 having a strikingly larger representation from the higher teaching ranks than did the early sessions of the school.

It is not possible within the limits of a short article to give an adequate picture of the work of the two sessions and but a few of their more important features can be mentioned. One of the most characteristic features of the session on engineering drawing and descriptive geometry, aside from the excellence of the lectures by staff members, was the number and quality of the prepared discussions presented by members of the group. These discussions, together with the formal lectures themselves, gave a summary of practices and of points of view on the more important phases of instruction in drawing and descriptive geometry that represented nearly, if not indeed quite, the entire range of practice in American institutions and thus gave the members a comprehensive view of their field of work as well as a summary of the methods of the ablest



THE CIVIL ENGINEERING SESSION OF THE S. P. E. E. SUMMER SCHOOL FOR ENGINEERING TEACHERS, YALE UNIVERSITY, JULY, 1930.

The Engineering Drawing and Descriptive Geometry Session of the Summer School for Engineering Teachers June 1930

teachers of their subjects. Lectures by engineers and chiefs of drawing divisions of industries similarly presented a view of drafting and design practices which formed a valuable supplement to the discussions of teaching and furnished a correlation of methods of instruction with the requirements of actual engineering methods.

A further feature of the drawing session was an excellent series of inspections of Pittsburgh industries, with special reference to their drawing and design departments, illustrating how the principles of drafting and design as well as the organization of those departments are actually carried out in practice.

At the conclusion of the session a dinner was held with Dean Gardner C. Anthony as the guest of honor. As in others of these concluding summer school dinners, which have become a regular feature of the sessions, the members "broke training" by songs, "stunts," and general good fellowship.

Undoubtedly the most outstanding feature of the civil engineering session was the size and the quality of the teaching staff. Included among its members were some of the ablest teachers and practicing engineers of the profession; the roster, in fact, reads much like a section of "Who's Who in Civil Engineering." The present president and most recent past president of the American Society of Civil Engineers, Mr. John F. Colman and Dean Anson Marston, respectively; Deans F. E. Turneaure, Richard G. Tyler and C. C. Williams; Professors J. C. Tracy, J. K. Finch, H. F. Moore, Charles M. Spofford, George E. Beggs, A. H. Fuller, W. K. Hatt, Clyde T. Morris, Francis P. Witmer, Charles M. Allen, Gordon M. Fair, Elton D. Walker, S. M. Woodward, Thomas R. Agg, and R. L. Morrison, to mention only a few, were included. Engineers from the field of practice on the staff included such men as Alfred D. Flinn, Director of Engineering Foundation, F. R. McMillan and H. F. Gonnerman, respectively Director of Research and Laboratory Manager of the Portland Cement Association, A. G. Bruce, Engineer, U. S. Bureau of Public Roads, Samuel Eckles, Chief Engineer, Pennsylvania State Highway Department, Thaddeus Merriman, Chief Engineer, Board of Water Supply of New York City, George B. Ford (since deceased), Director of the Regional Plan of New York, William Bowie, Chief, Division of Geodesy, U. S. Coast and Geodetic Survey, Michael I. Pupin, Leon S. Moisseiff, Consulting Engineer to the Port of New York Authority, and Messrs. E. P. Goodrich, Charles S. Whitney, O. E. Hovey, Clarence W. Hudson, Frank P. McKibben, D. B. Steinman, J. A. L. Waddell, William P. Creager, T. Chalkley Hatton, Robert S. Weston, Maxwell Halsey, Arthur G. Hayden, and Fred Lavis, whose names are so well known in civil engineering as to need no comment.

Of special interest at the civil engineering session was a series

of lectures and discussions of educational principles and practices conducted by Professor Francis T. Spaulding of the Graduate School of Education of Harvard University. These lectures, or a portion of them, will appear in subsequent numbers of the JOURNAL.

Another feature of the session, provided as a means of having the large group become well acquainted early in the session as well as for other reasons, which proved both enjoyable and instructive, was a stay of three days at the Yale Engineering Camp at East Lyme, Connecticut. There the members renewed their acquaintance with the life of the civil engineering camp, lived in barracks, swam in the lake, held a "regatta," played baseball, pitched horse shoes, sat around camp fires, swapped yarns and in other ways thoroughly enjoyed themselves. During the stay at the camp the portion of the formal program devoted to organization and methods of teaching courses in surveying both in the field and in the classroom was carried out.

The programs of the two sessions of 1930 differed, each being adapted to the needs of the group and of the division of the curriculum under discussion. That of the drawing session was arranged in but one division common to all the teachers attending. It included, in order of presentation, study of the aims and purposes of courses in engineering drawing and descriptive geometry, content of these courses, methods of administration, principles and methods of teaching, examinations and tests of achievement and other similar topics. These were supplemented by lectures on the applications of the principles of drawing and descriptive geometry in practice, drafting standards, the history of graphic representation, and by inspections of drafting and design practices in industry. Included in the program were also the work and reports of a number of committees of members of the group on aims and purposes of drawing courses, methods of instruction, tests of achievement and other subjects.

The program of the civil engineering session was arranged in two principal parts: one, common to all in attendance, was devoted to educational principles and practices, history of civil engineering, surveying, materials of construction, professional ethics, business relations of the civil engineer, the teaching of personnel administration, and other topics of interest to all teachers of civil engineering. The remainder of the program was divided into three parts, or divisions, devoted respectively to structural engineering, sanitary and hydraulic engineering, and highway and railway engineering. These divisional meetings were attended by teachers of the subjects mentioned. Methods of instruction and content of subject matter were discussed in greater detail both by staff and group members in these divisional meetings.

No written statement about the summer school sessions can convey an idea of their most important aspect: the spirit of earnestness and of enthusiasm with which those present entered into the work. At both sessions this spirit was maintained unabated until the very end.

A number of trips of inspection to nearby engineering works. including certain notable projects in New York City, and other trips of general interest were arranged as part of the program. Among these was an inspection of the battleship Mississippi, on invitation of the U. S. Navy Department.

At both the drawing and the civil engineering sessions a number of the members and of the staff were accompanied by their families. Receptions and other entertainments were arranged for the ladies of the groups by the families and the officers of the local faculties.

At Pittsburgh the group was quartered in dormitories of the Carnegie Institute of Technology; at Yale the Vanderbilt Sheffield Dormitories were set aside for the summer school. In both instances the accommodations were splendidly adapted to the needs of the members.

The drawing session was under the direction of William E. Mott, Director of the College of Engineering, Carnegie Institute of Technology, Local Director, Professor H. M. McCully of the same institution, Secretary, and Thomas E. French of Ohio State University, Chairman of the Teaching Staff. The staff of the civil engineering session was headed by John C. Tracy, Professor of Civil Engineering, Yale University, Local Director, and Roscoe H. Suttie of the same institution, Secretary.

Publication of a number of the papers presented at the two sessions of the summer school begins in the present number of the "Journal," and will continue in subsequent issues. These papers will also be printed, as in the past, as separate monographs and will be available for quantity distribution by addressing the office of the Director of the S. P. E. E. Summer School, 99 Livingston Street, Brooklyn, N. Y.

ANNOUNCEMENT OF THE SESSIONS OF 1931

By action of the Society's Council at the Montreal meeting, invitations of the University of Michigan and of the University of Minnesota for the holding at those institutions, respectively, of sessions of the summer school on chemical engineering and on the teaching of mathematics to engineering students were accepted, contingent upon the completion of financial and other arrange-

ments. Final announcement concerning these sessions as well as details as to dates, programs, members of the staffs and other matters will be published in subsequent numbers of the JOURNAL. It is probable that the session on chemical engineering will be held immediately after the Society's annual convention, to be held at Purdue University in June, and that the session on mathematics will be held in the latter part of August immediately preceding the dates of the annual meetings of the American Mathematical Society and the Mathematical Association of America both of which are to be held at Minneapolis.

While no limit will be set on the attendance at either of these sessions except as may be necessary by reason of the accommodations available, it is advisable for teachers who may expect to at tend to make early reservations. This may be done by addressing a letter stating the institution and teaching rank of the applicant to the Director, S. P. E. E. Summer School, 99 Livingston Street, Brooklyn, N. Y.

THE ENRICHMENT OF EXPERIENCE IN THE DEVELOPMENT OF THE TEACHER *

By JOHN C. TRACY
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I am to speak on "The Enrichment of Experience in the Development of the Teacher." By *experience* I mean more than teaching experience, more than practical experience,—I mean the *sum total* of a man's personal experience. By *enrichment* I mean more than the mere broadening of experience, more than the deepening of experience,—I mean all that enrichment implies.

I shall remind you how inevitably and vitally experience affects our thinking, our personal qualities, and our influence as teachers, and I shall try to state some of the most important guiding principles that we should follow in seeking to enrich our experience.

Experience is only in part a matter of age. One man may gain a richer experience in a few years than another may acquire in a lifetime. Nevertheless, my message, if I have any real message, is intended primarily for the younger men. The thoughts that I bring to you are neither new nor original, as you will see, but it is my hope that the total effect of what I say may be to influence some of you to seek early in life that enrichment of experience which some of us have gained needlessly late in life, if at all. My old teacher, Professor DuBois, used to say: "Good advice from a bad man is worth something." On this principle, if on no other, an older man may venture to speak to younger men on the general subject of experience.

Let us begin by thinking about thinking, particularly the effect of experience on thinking. We are constantly storing up in our mind images and concepts which our senses bring to us; we are continually adding to the picture gallery of our imagination mental photographs formed by exposures to all sorts of experiences. These images or concepts constitute the thought material upon which our mind works in reflective thinking or in meeting new experiences. Thinking does not consist merely in recalling this thought material, but thinking cannot proceed without it.

Much of our thought material is second-hand in the sense that it is gained through the experience of others. When, for example, an object or an emotional experience is pictured or described to us,

* A lecture delivered at the Civil Engineering Session of the S. P. E. E. Summer School for Engineering Teachers, Yale University, July 14, 1930.

we add a new image or concept, and this addition is in itself a first-hand experience, but the image or concept is second-hand, because it is not the result of direct contact with the object or the emotion itself. The important distinction between first-hand and second-hand thought material is too frequently overlooked or forgotten, not only by teachers, but by many others interested in education.

The experience of an individual is so limited that much of his most important thinking, particularly abstract thinking, must necessarily proceed from second-hand thought material. Rational knowledge of such things as mathematics and the sciences, indeed abstract conceptions of all kinds come to us through the cumulative experience and thinking of the ages. But in this discussion I am mainly concerned with the fund or store of experience and facts, of images and concepts that we gain first-hand. I have been speaking of this thought material as a sort of building material from which we construct our thoughts. A building is the product of certain processes of construction applied to building materials. It is possible and often desirable to discuss many of the effects of building materials on methods of construction and upon the building itself without going deeply into the technical methods of construction. Similarly it is possible to discuss some of the important effects of thought material on thinking and upon the results of thinking, without going deeply into methods of thinking, and this is what I now purpose to do. May I ask you to remember, therefore, as I proceed, that I am not discussing primarily *methods* of thinking, but rather the effects of our thought material upon our thinking and upon ourselves.

FUNDAMENTAL FACTS AND PRINCIPLES PERTAINING TO THOUGHT MATERIAL

There are certain familiar facts and principles pertaining to thought material that are so fundamental that we shall need to keep them in mind throughout this discussion.

First Fundamental: Images and Concepts Gained from Experience are Real to Us.—Let me illustrate. The man who habitually lives in a city gains from experience all sorts of images of a city and its life which are *real* to him, but his images of a wilderness are usually vague and unreal. The sailor's image of the sea is *real* but his image of a desert is not. The man in the tropics has a vivid conception of a hot climate but very little conception of a cold climate. These illustrations will suffice to show what I mean when I say that first-hand thought material gained from experience is real to us.

Second Fundamental: Experience Modifies or Changes Much of Our Second-hand Thought Material.—The images and concepts gained from experience not only modify and vivify images and concepts that we have acquired second-hand, but they also change much of our second-hand thought material to first-hand material. To realize the truth of this we have only to compare our image or concept of *any* sight, sound, smell, taste or feeling before and after experiencing it, or to compare our concept of any experience before and after we have had it. For example, I may have a fairly correct image of the Capitol Building at Washington before I have seen it, but my first sight of that building will surely modify and vivify my image, or I may *think* I have a correct concept of teaching before I have taught, but the experience of teaching will almost inevitably change my concept and continue to change it as long as I teach.

Third Fundamental: Much of Our Best Thought Material Can be Gained Only through First-hand Experience.—I am thinking here not of rational knowledge and abstract conceptions, but more particularly of our acquaintance with the world of material things and of our conceptions that have to do with personality, character and the fulness of a man. The truth and importance of this second fundamental will become clear from one or two simple illustrations. No one is ever fully prepared for his first sight of the Grand Canyon of Arizona, no matter how many descriptions he may have read or pictures he may have seen of this great natural wonder. The moment he stands on the rim his whole conception of the canyon is changed. Awed and overwhelmed by its grandeur and beauty, he instantly gains an image that ever more will enrich his thinking. When he attempts to convey this image to another, he realizes how helpless he is to describe or picture the Grand Canyon. What is true of this great canyon is true of much in nature all about us. Adequate images or concepts of mountain and plain, river and sea, sun and moon, thunder and lightning, sunset and sunrise are gained only from direct experience. A similar assertion can be made concerning a great variety of images which our senses bring to us. It is true also that adequate concepts of deep emotions are acquired only through experience. One has no adequate concept of sorrow, for example, until one has suffered a great sorrow; or of joy, until one has experienced a great joy. Thus it is that in the natural world and in the spiritual world alike, experience is often not merely the best teacher, it is in fact the *only* teacher.

Fourth Fundamental: We Gain Our Thought Material Largely in Accordance with Our Likes and Dislikes, and as We Extend Our Experience We Multiply Our Likes and Dislikes.—When we like or dislike anything we are interested in it and when our

mind is exposed to images and concepts which interest us, the impressions are likely to be clear and lasting. We are not likely, however, to gain much from experiences which do not interest us because our mind is not spontaneously active in acquiring thought material to which we are indifferent. By increasing the variety of our experiences we may increase our likes and dislikes and thus the variety of our interests.

Fifth Fundamental: The Quality of Our Thinking Depends upon the Quality of Our Thought Material.—It depends also upon methods of thinking, but we are not concerned here with these methods. This fifth fundamental may seem a mere platitude, but it may be well to discuss just how experience by improving the quality of our thought material improves the quality of our thinking. (*a*) Experience by making our thought material real to us vitalizes our thinking. What is real to us interests us, and what interests us stimulates our thinking. (*b*) Experience broadens and tempers our thinking. As we add to the variety of our experiences we multiply our likes and dislikes and consequently our interests and our thought material. We thus increase our capacity for thinking broadly. Provincial thinking is, of course, due largely to limited experience. As we broaden our experience we tend to become more open-minded and tolerant. The more we extend our experience, the more we realize our own limitations. We thus gain a genuine humility that tempers and regulates our thinking. (*c*) Experience clarifies and corrects our thinking. A prime requisite for clear thinking is a clear mind; the clear images and concepts gained from experience contribute greatly to this quality of mind. Moreover, experience corrects our thinking. A man in the business world who thinks incorrectly rarely escapes the consequences—he is likely to suffer; but this is not always true of a man in academic life. Unless we have some of the corrective checks which experience outside the college almost inevitably produces, we may for a long period of time have a mistaken conception without getting hurt. As our experience clarifies, broadens and tempers our thinking, however, we gradually replace our misconceptions and prejudices by truer and more exact images and concepts and thus correct our thinking.

The gist of the whole matter is that experience by enriching our thought material enriches our thinking. This is the principal underlying thought in my whole discussion.

Sixth Fundamental: We Inevitably Reveal by What We Say, by What We Do, and by Our Attitude toward Life the Quality of Our Thought Material.—The emphasis here should be on the inevitableness of the self-revelation. It is so easy to reveal unconsciously the quality of our images and concepts! Indeed the

quality of a man's thought material pertaining to a given subject is often revealed by his spontaneous reaction to a single word. What, for example, is a man's spontaneous reaction to the word "war?" This sixth fundamental has a direct and important relation to the influence of a teacher, as I shall try to show later.

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I have spoken thus far as if experience inevitably improves our thinking. This of course is not true. Experience may be detrimental to thinking. For example, the broadening of experience may lead to an indecisive openmindedness, a weak vacillation in thinking. Too intense or too prolonged an experience may leave one embittered, cynical, and prejudiced. Association with others in mass thinking may mean loss of independence in thinking. The effect on our thinking of any experience depends, first on how well we are prepared to meet that experience, and, second on our methods of using the thought material which we gain. In general, however, the normal effects of experience on thinking should be highly beneficial, and it is with these normal effects that we are here concerned.

It may be well at this point for me to emphasize again the fact that I am not discussing methods of thinking. Such a discussion would lead us away from our main thought which, may I repeat, is merely this: That if our thinking is to be of high quality our thought material must be of high quality, and that it is possible through varied experience constantly to improve the quality of our thought material. Thinking depends more upon experience—upon the possession of rich, pregnant thought material—than we are frequently led to suppose. We may actually nurture the mind by providing it with the best food for thought—not merely by reading and study, but through first-hand experience.

I have summarized some of the more important effects of experience upon our thought material and upon our thinking in order that we may study these effects in connection with the interplay of thought between teacher and student. Some teaching has been described as merely the process of getting information from the notebook of the teacher to the notebook of the student without it passing through the mind of either. But assuming that the minds of both teacher and student are active, how is this activity affected by the accumulated experience of each? I shall speak only briefly of the student, more at length of the teacher.

THE STUDENT AND HIS EXPERIENCE

We too often forget that the student's appreciation or lack of appreciation depends upon his own first-hand experience. This is

true in every subject that he studies. Let us take, for example, English literature. In Whittier's "Snow Bound" occur these lines:

> "No cloud above no earth below
> A Universe of sky and snow
> The old familiar sights of ours
> Took marvelous shapes, strange domes and towers."

Only a student who has experienced a hard snow storm can visualize fully the scene thus depicted, or can appreciate what it means in Whittier's words to "cut the solid whiteness through."

Let us take as another example Tennyson's "Crossing the Bar" which begins:

> "Sunset and evening star
> And one clear call for me,
> And may there be no moaning of the bar
> When I put out to sea."

Students frequently vote this as their favorite poem; why I do not know. It surely is not because its theme is death, for that is generally remote in the mind of the student, nor is it merely because of its beauty of expression. Is it not, perhaps, because all through the poem there is a manly ring of *courage* that challenges death, and *courage* is something students appreciate from their own experience.

Let us take another example, the single phrase "He who seeketh his life shall lose it." Few men at the beginning of life can appreciate the profound significance of this paradox. It takes us a life time of experience, in which we try at first the more selfish pursuit of life and happiness, to convince us that we *really* must lose our life to find it.

These examples indicate that the student necessarily interprets what he reads or hears in terms of his own experience—his own images and concepts. When these images or concepts are inadequate there is a lack of appreciation which results in a lack of interest. I have in mind a series of excellent lectures given by practicing engineers to a class of earnest students in engineering. In the discussion periods that followed the lectures it became evident that the students did not appreciate and were not interested in many of the most important portions of these lectures, probably because of their lack of experience not only in engineering but in life itself. We teachers never quite cease to be surprised that reading and study and lectures fail to do for the student all that we expect. We can teach the student *methods* of thinking, but we cannot teach him to think. We forget that the student's mind cannot work on images and concepts which he does not possess and

cannot obtain except through first-hand experience. We are disappointed because the student does not have thought material which it has taken us years of experience to acquire.

THE TEACHER AND HIS EXPERIENCE

Let us turn now to the teacher and his experience, not merely his teaching and his practical experience, but his whole life experience. Let us consider the effect of experience on the teacher's thinking, on the teacher himself, and upon his influence.

Effect of Experience on the Teacher's Thinking.—In accordance with principles previously stated, the quality of our thinking depends largely upon thought material gained from experience and *only* from experience. We have seen how such thought material may vitalize, broaden, temper, clarify, correct, and enrich the teacher's thinking. It enables him to eliminate from his thinking the trivial or unimportant; when experience has been great enough to make one big-minded he has no time for non-essentials. It creates a cosmopolitan mind. It also creates a colorful and vivid mind and hence a corresponding capacity for statement. A wide experience in the range of human situations enables the teacher to put things in terms real to the individual. Experience helps the teacher to think more spontaneously and less self-consciously—a most important gain because his best thinking is done when he is not conscious of it.

Effect of Experience on the Teacher Himself.—It is questionable whether we are justified in separating the effect of experience on the teacher's thinking from its effect on the teacher himself. "As a man thinketh so is he." There are, however, certain effects, which, though the direct result of thinking, become manifest in the behaviour of the teacher. Experience enables the teacher gradually to find himself. If, on the one hand, he has an inferiority complex, experience brings to him thought material of such varied and intense interest, that thought of self is expelled and diffidence gradually disappears. If, on the other hand, he has a superiority complex, experience begets a genuine humility and an openminded, receptive attitude toward all truth. It tends to eliminate pretense and academic pose. It checks the tendency to ideals of impossible perfection, and helps in other ways to maintain a mental balance. Experience enables the teacher to speak with authority because he is dealing more frequently with first-hand images and concepts. What he says is more readily accepted. Finally, experience tends to make the teacher more alive and dynamic with personal power and magnetism, because he is more open to life all about him and because life abundant comes from the enrichment of experience.

Effect of Experience on the Teacher's Influence.—All of us will agree that nothing is more important in education than the influence of the teacher in helping the student to develop methods of thinking, methods of work, and the personal qualities that enter into a fine character. Each of us can think of some teacher of influence who was a constant source of inspiration. To sit under a great teacher of this sort is in itself a liberal education no matter what subject he teaches.

Every teacher has an influence for better or worse whether he knows it or not and whether he desires it or not. The teacher is no exception to the general rule that a man will inevitably reveal by what he says, by his attitude toward life and by his own life the quality of his thought material. Students are as quick to appraise him by such revelations as by his knowledge of the subject that he teaches.

A genuine and enthusiastic interest in the student is assumed as part of the passion for teaching, without which no teacher can have the right kind of influence. But interest and good intentions alone are not sufficient. The teacher must have an abundance of thought material upon which his mind may work naturally and easily. Influence cannot be pumped from a teacher into a student, it must flow naturally and unobtrusively. Someone has said that "influence is the effluent of affluence." One interpretation of this epigram is that influence flows naturally and spontaneously from a reservoir of thought material which has been gradually stored up from a wide and varied experience. The teacher can give out nothing that he does not have, nor can he help giving out that which he does have. Let him vitalize, broaden, clarify, temper, and enrich his thinking by enriching his experience and his influence will perforce become proportionately greater.

THE ENRICHMENT OF EXPERIENCE

I have discussed at length the effect of experience on our thought material, on our thinking, on our personal qualities and on our influence. I wanted to show in a clear and definite way how essential—how very essential—the enrichment of experience is in the development of the teacher. It now remains for me to suggest *how* we may enrich our experience. This is far more difficult, because, for the most part, each of us must solve this problem for himself. It may be possible, however, to state some of the more important guiding principles.

GUIDING PRINCIPLES IN ENRICHING EXPERIENCE

Cultivate a Thorough Appreciation of the Importance of Experience.—The more we realize the possibilities of the enrichment

of life through the enrichment of experience the more likely we are to have that constant motivating desire which leads us to seek experience. Such a desire is marked by an eager curiosity which, judiciously cultivated, will result in both broadening and deepening our experience. We appreciate the importance of teaching experience and practical experience, but we do not always appreciate the importance of other experience. We must if we are to seek it. If we only care enough about experience we shall certainly attain it.

Seek First Those Experiences in Which You are Interested.—In discussing the effect of experience on our thought material I stated as a fundamental principle that the nature of the thought material which we store up depends largely on our likes and dislikes, and that the mind is not spontaneously active in acquiring thought material to which we are indifferent. We are sure to concentrate on that in which we are interested, whether we like it or dislike it. Moreover, the surest and perhaps the only way to acquire a new interest is to associate it with an old interest. In seeking to enrich our experience we are likely to make the mistake of beginning with some experience in which we have no real interest but in which it is considered to be the proper thing to be interested. How much time we all have wasted, for example, in trying to admire what others consider admirable. It is better, at least at first, to find our own vein in which our richest interest lies and from which we may gain thought material that is real and vital to us. The investigator who has the flair for research and who is working in a field in which he is greatly interested finds that his quest after truth is not drudgery but fascinating work. So it should be in the quest for experience. Do not misunderstand me. We cannot and should not always follow our inclinations. There are certain experiences that every man should seek whether he is interested in them at first or not. But if we start on the quest for experience in something in which we are interested and follow the quest with eager curiosity, we are sure to be led into strange areas in which we find new interests of which we had not dreamed. Nor should we forget that many of life's richest experiences are those we do not like and would not seek, experiences like extreme physical hardships, bitter disappointment, intense pain, and deep sorrow. Such experiences test and develop our whole manhood. Although they come to all of us unsought, they are of such vital interest that they leave vivid and unforgetable impressions—images and concepts—that enrich our thought material and hence our lives. But we are more concerned now with those experiences which we deliberately seek. Again may I repeat, we should seek first those experiences in which we are interested, but not without the hope and expectation that they will lead to others in which we may become interested.

The extent to which the whole circumference of our experience is thus gradually enlarged is a measure of what we get out of our experiences.

Seek Experience for its Own Sake and Not Primarily Because it may be Useful.—There is a real danger in seeking experience for a definite purpose, such, for example, as to improve our teaching. In the first place, this kind of seeking is likely to result in an habitual effort to impress others with our experience. To be everlastingly conscious of our experience begets a constant temptation to show off before students, a form of egoism and egotism that is fatal to a teacher's influence. In the second place, the man who seeks experience in order to retail it to others is not free to keep emotionally wide open to those new impressions—new images and concepts—that are most enriching. Experience should be gained not so much from conscious effort as from habitual exposure. Disinterestedness in seeking experience paradoxically increases interest, and from this increased interest come new images and emotions that are not as freely acquired if at all, by conscious effort. It we wish to be mentally prepared for the enriching effects of any experience we should try to free ourselves from egoistic preoccupation about the results of that experience.

Seek a Well Rounded Experience and Realize that Seeking it Means Work.—This may seem inconsistent with the second and third guiding principles that I have just stated. In the first place, how can we seek a well rounded experience if we seek only those experiences in which we are interested? You will remember that what I advised was to *begin* with experiences in which we are interested as the surest way of approach to those in which we are not. In the second place if it means hard work, how can we expose ourselves to experience without a definite purpose and without conscious effort? There is a distinction between having an underlying purpose and letting that purpose intrude upon our consciousness during an experience, and there is also a distinction between working in order to gain an experience and making work of an experience. We may, for example, have a definite desire or purpose to enrich our experience by traveling, we may make a determined initial effort in order to travel, and we may be compelled to work while we travel, but if we are constantly keyed up to our purpose and are continually conscious of effort, we shall miss much of the enrichment that we desire. In seeking any rich experience, we need to confine our ambitions, our anxieties and our conscious efforts as far as possible to our general purposes and plans, and then, in the words of William James, to "*unclamp* our intellectual and practical machinery and let it run free." Thus relieved from inhibitions, the mind is sensitive to the impressions brought to it

by the experience, much as the camera film is sensitive to the images brought to it by the lens. We need to avoid, on the one hand, the danger that comes from seeking experience for a definite purpose and through conscious effort, and, on the other hand, the danger that lies in the failure to seek experiences in which at first we are not interested.

METHODS OF ENRICHING EXPERIENCE

I shall not dwell long on methods of enriching experience. The principal thing is to have a constant and eager desire for such enrichment. If I have stimulated to some degree such a desire my main purpose is accomplished. Having that desire, each of us can analyze his own experience and seek to enrich it. No two of us could or should follow exactly the same methods. It is a personal problem on which each individual, as long as he lives, must be continually working. I shall, however, suggest briefly several general sources of experience that may be helpful.

Contact with Men.—I place first, as possibly the most important, contact with men. Much of a teacher's time is spent with men younger than himself, whose thought material, for the most part, has not been gained from first-hand experience. We peculiarly need to talk with men of varied experience, particularly men outside our own teaching and engineering professions. Most of us, I think, find it interesting to talk with all kinds of men with different points of view, rich and poor, educated and uneducated, reasonable and unreasonable, workers and loafers, Americans and foreigners. If we have such an interest and follow it habitually, it will bring to us thought material of unbelievable variety, rich in new images and concepts.

Volunteer Civic Service.—A second general source of experience is volunteer civic service. Mr. Hoover has said that: "Engineers should exert themselves in our national engineering policies or the next generation will face a lower instead of a higher standard of living than ours." As an individual, each of us may feel rather helpless to respond to this challenge of Mr. Hoover's, but we can at least begin by exerting ourselves in volunteer service for the community in which we live, not merely in engineering policies, but in any form of civic work for which we are fitted. This is not only a duty, it is an opportunity. If we assume our fair share of civic responsibility in our own community, we shall, first of all, be brought into contact with all kinds of men, as I have just advocated. In addition, we shall gain first-hand experience that is likely to modify or entirely revise many of our ideas. To serve on a city council, a city commission, a board of education, or some other

municipal body is an experience that brings new concepts of problems in government. To serve as a member of a chamber of commerce, a service club, a community chest, a welfare organization, or some other good civic organization is an experience that brings new concepts of community problems and civic responsibilities. Volunteer civic service involves work but it may become fascinating as play. It is its own reward—not merely in the satisfaction that it brings, but also in the abundant thought material that it inevitably produces.

Travel.—A third general source of experience is travel. Even the most unobserving is bound to acquire new images and concepts when he travels. Moreover, travel affords one an opportunity to come in contact with all kinds of people. The value of travel is greatly lessened, however, when one merely rushes from place to place with no intelligent curiosity and with little thought. On the other hand when one travels with too conscious an effort to inform himself, he may lose much of the benefit he should obtain. Here, as elsewhere, the best experience is gained by exposure rather than by conscious effort.

Recreation.—The fourth source of experience is recreation. We are too prone to think of play as a waste of time, or, at best, as a means of healthful exercise. But play is much more than this, it brings to us some of our richest experiences. Every teacher should have at least one hobby and the essence of a hobby is that it shall be play, not work. Our hobbies, if followed far enough, will lead us to all sorts of new experiences, and a single hobby, such for example as fishing and camping, may be an experience that is a liberal education in itself.

I have ventured to suggest these four general sources of experience not because they are necessarily the most important, but merely to stimulate your own thinking on the practical side of this discussion. Anyone of us could continue indefinitely to think of various methods of gaining a varied experience and, as already stated, the seeking of such an experience is a problem that each individual must work out for himself. Moreover, may I again remind you that if we constantly have a mental welcome for new images and concepts and if we continually expose our mind to such new impressions, rich experiences pleasant and unpleasant will come to us unsought.

DIFFICULTIES OF ENRICHING EXPERIENCE

Some of you may be thinking of the many serious practical difficulties which I have seemingly overlooked. Where can a teacher get the necessary time or money or both with which to seek this

varied experience? We engineering teachers have already an almost impossible task. We are members of two professions, teaching and engineering, either one of which could occupy our whole time. When we are young we must work hard and continuously to make good. When we are older, responsibilities come pressing in on us and fill our lives to overflowing. The incomes of most of us are relatively small. There are so many things which we should like to do to enrich our experience, but we seem bound hand and foot. All this I must admit. We cannot afford to seek the experiences that we desire, yet we cannot afford *not* to seek them. In the face of these difficulties may I suggest, however, some mitigating conditions:

(*a*) The nature of the engineering subjects that we teach and of the engineering work that we do in connection with research or with teaching compels us to maintain outside contacts. In this respect we are more fortunate than many college teachers.

(*b*) Some of the best sources of experiences, such as contact with men, volunteer service, and recreation, are open to us in the community in which we live and often without expense.

(*c*) Travel may seem expensive and difficult especially with a wife and small children, but it is now possible for one to take his whole family in his automobile and gradually cover all sections of our country at a cost not much if any in excess of the cost of living at home. Hundreds of workingmen on small incomes are doing this and so can we.

(*d*) There never was a time when it was so easy to gain new images and concepts. Modern methods of photographing and projecting, of recording and reproducing bring us sights and sounds from all parts of the world. In spite of the trash that at present makes up so large a part of the movies and of the radio, we are able to see vividly pictured places and peoples that we could not visit, and to have reproduced marvellously fine music and important speeches that otherwise we could not hear. Never before has there been such easy access to parks, gardens, exhibits, theaters, museums, lecture halls, libraries and numberless other agencies for bringing us new images and concepts. Moreover, the very complexity of life all around us affords unprecedented opportunities for acquiring new thought material of great variety and importance.

But when all is said and done, it must be admitted that to enrich our experience is no short, easy undertaking—it is a long, difficult achievement. But, as I have said, experience comes not so much from constant effort as from an eager desire to expose oneself to a great variety of enriching experiences. If this desire is sufficiently strong, we shall find a way to satisfy it.

I have now covered the most important part of my subject. I have tried to explain the effect of experience on our thinking, to emphasize the need of varied experience, and to suggest how we may expose ourselves to such experience. I would be inclined to stop here did I not feel that I might be misunderstood and my message weakened by the seeming omission of what is commonly considered the two most important educational experiences. It seems necessary that I should say something about the educational experience that we obtain through reading or study, and the cultural experience that we gain through exposure to cultural influences.

READING AND STUDY

You may be surprised that I have not included reading and study as a means of enriching experience. Surely, if we are to benefit by the accumulated experience of all men, if we are to carry with us into the future the lessons of the past, if each generation is not to start all over again we must read and study. Moreover, reading and study *prepare* us to make the most of our own experience, for the richest experiences come most surely to the mind which is prepared. I have deliberately refrained, however, from discussing reading and study as a means of enriching experience, partly because to do so would be to repeat what you have heard so many times before, and partly because if I should dwell at length on reading and study, I might obscure the importance of that kind of experience which I have been urging, namely, experience outside the academic world. We teachers already are too prone to substitute book knowledge for experience. At best, reading and study bring to us second-hand experience. Do not misunderstand me, I do not undervalue such experience. Much if not most of our best thought material must necessarily be second-hand. The experience of each of us, however inclusive and deep, is inevitably limited, and each of us would live within exceedingly narrow boundaries if he were confined to the area of his own individual contact with things and persons. It is only through reading that most of us can come in contact with great men and gain the information and ideas that come from great minds. The experience of meeting great minds through reading can immensely expand our very local experience, projecting it over wide areas, and by integrating our reading experience with that local experience give to us a deeper understanding. The importance of storing up thought material in this way cannot be over-estimated, but all this in a sense is wholly outside of my purpose in speaking to you. I am not now concerned with the usual process of learning and I can contribute almost nothing to a discussion of reading and study except perhaps this:

To get the greatest benefit from reading, as from any other experience, our minds should be prepared for it, that is they should be stored with as great a variety as possible of true images and correct concepts that have been made real to us through our own experience.

The teacher who holds himself aloof from the world and attempts to enrich his experience solely by reading and study will encounter serious difficulties. He is in danger of transferring to his own mind from the minds of others thought material which his limited experience in life does not permit him to make wholly his own. He is unable to appreciate much that he reads because he lacks the experience which would make it real to him. Reading is supposed to stimulate thinking, but it is too often a substitute for thinking. To read and to reason without adequate experience as a check is likely to lead to seemingly logical but actually fallacious conclusions. This is shown by much that has been and is being written in such fields as economics, sociology, philosophy, and religion,—and, may I add, as engineering and education.

We have in a sense a necessary circle of prerequisites. Reading and study are necessary to prepare the mind for the impressions that come from experience, but experience is necessary to prepare the mind for reading and study. For example, we need to read and study extensively to prepare ourselves for a trip around the world, but we need a trip around the world to prepare ourselves for this kind of reading and study. After such a trip we may re-read with added interest and appreciation, indeed we can hardly pick up a magazine or a book without becoming interested at once in something that pertains to places and people that we have visited and seen, or to other experiences that we had on our trip. We cannot then afford to neglect either element in this circle of prerequisites. Most of us appreciate, I think, the need of reading and study as a preparation for experience. We must appreciate as well the need of varied experience as a preparation to reading and study.

As I pass from this topic of reading and study, may I suggest that in seeking to enrich our experience by reading, we begin with that which interests us and gives us pleasure—a guiding principle already recommended for seeking experience in general. Many a man's interest in reading has been killed by his trying to read what conventional standards seem to require. In biography, for example, conventional standards require that we read the lives of certain outstanding men in history, but it may be better for us to begin with men who, because they are within the range of our own experience, interest and inspire us more. No one can prescribe for a man what he ought to read, for a man can read with appreciation only that for which his mind is prepared. We enjoy reading what

we really appreciate, and as experience adds to the extent and variety of our images and concepts, we appreciate and enjoy a greater variety in our reading. Thus enrichment of experience is the surest—I am tempted to say the *only*—approach to a genuine and independent understanding and appreciation of the best thought in literature.

CULTURE

The topic "Enrichment of Experience" may have led some of you to expect that I would speak about culture, but I have intentionally refrained from doing so. I should be open to justly severe criticism however, if I should fail to recognize culture as an important part of experience. But when one speaks of culture he should make clear just what he has in mind. No two of us, perhaps, have the same conception of what culture really is. As defined by Mathew Arnold, culture is "the acquainting ourselves with the best that has been known and said and thus with the history of the human spirit." According to this, culture is largely if not wholly the acquisition of knowledge. It may not be fair to Mathew Arnold to quote this definition apart from its context, but it is fair to say that this conception of culture as wholly and coldly *intellectual* is all too prevalent. We frequently assume that a certain type of knowledge to be obtained from so-called cultural courses is the essence of culture. Too often the result is merely a thin veneer that we erroneously call culture, which taken by itself may be essentially selfish and egotistical. It frequently develops into the self-conscious pose of the "highbrow," as provincial as it is amusing. Consequently "culture" is a word that is rapidly being discredited. If we are to save it from disrepute we must be careful to use it in its true meaning. Most of us, I think, associate with a man of culture not only mental cultivation and learning, but also refinement, good taste, good manners, and the ability to express himself with power and charm. We like to think of him as a gentleman, a man of good breeding, courtesy and kindliness. But such qualities as courtesy and kindliness are not primarily intellectual, for like all true instincts of a gentleman, they spring from the heart. How futile it is to expect culture in this sense to be gained merely from cultural studies if we lack the experience that enables us to interpret and appreciate. It takes well nigh a life time for culture to develop in all its fullness. In the truly cultivated mind there must be stored up images and concepts that are real because they have been gained by first-hand experiences—images and concepts that enable one to appreciate the true, the good, and the beautiful. To the thought material acquired by reading and study must be added thought material that comes from

experience and experience only. Culture in its narrow sense is no substitute for experience, culture in its true sense includes experience. In the last analysis, culture is rich, varied experience.

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In discussing the enrichment of experience in such detail and at such length as I have today, I may have seemed to claim too much for general experience. Surely some of the greatest thinkers in history were seemingly men of limited experience. Kant, for example, is said never to have been outside the town in which he lived. But, may I remind you, I have not been discussing rational knowledge or abstract thinking, nor have I had in mind greatness and genius. I have merely undertaken to consider the effect of a well rounded experience in the development of the teacher. Possibly I may seem to think that as compared with such experience there is little else of importance. I should regret leaving any such impression. I do not undervalue the necessity for complete mastery of the theory and practice of the engineering subject which we teach, or the importance of good teaching methods. I have taken all this for granted. I am conscious also of having omitted any adequate consideration of the necessary preparation for experience. As already stated, the richest experiences come most surely to the mind which is prepared. Education itself is an experience to prepare for experience. Neither have I ventured to consider how best to use experience as we acquire it—a discussion that would involve the whole art of thinking, to say nothing of human behaviour. No! My one topic has been sufficiently difficult. To undertake in a single lecture even to suggest the possibilities that lie in the enrichment of experience has taken about all the optimism and courage that I possess.

I would not have you think that I have singled out engineering teachers as men who need more than other men to enrich their experience. What I have said concerning the enrichment of experience applies to most men everywhere. But generally when a man fails to enrich his experience he and his friends are the principal losers, whereas when a teacher fails, his students are the principal losers. The implication, I think, is clear.

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In all of my discussion thus far I have been speaking as one teacher to another. When I began teaching nearly forty years ago I believed in the old motto "*Labor omnia vincit*"—work conquers all things. I thought that to be a successful teacher all that was necessary was to work hard, master my subject, acquire the best methods of teaching, and keep abreast of engineering practice. I have changed my mind. I see now that work does not conquer all

things and that to know ones subject, methods of teaching, and current practice is not enough. I regret that I did not realize this early in my career. I want you younger men to avoid such a mistake; to realize that it is easy to work hard and yet be absorbed in a routine so full of details and non-essentials that life is almost barren of rich experiences. I want you to be more certain than perhaps some of you are that to spend all of your spare time, including vacations, in work directly connected with engineering or education is *not* the best preparation for teaching. I wish that you would cultivate an irresistible desire to seize as many as possible of the daily opportunities for acquiring new images and concepts, and that at intervals you would break away from all of your regular work for some new and extended experience, so that you gradually but continually enrich your thought material and your lives. But all of this is from the point of view of a teacher. In closing may I speak briefly from the point of view of a father. It is from that point of view, perhaps, better than from any other that I can summarize what I have been trying to say to you.

The experience of having a son in college brings to a college teacher new concepts—strange ideas and beliefs bordering upon educational heresy. Somehow we do not seem to care whether a teacher knows a little more or a little less of his subject—we assume that he knows enough to teach his students. We even find that we do not get very excited about his teaching methods—we take for granted that they are reasonably good. The important question is: "What kind of a man is this teacher who is influencing my son during his impressionable age?" We should like to look into the mind of this teacher and see if he has stored there a great variety of worthwhile images and concepts that are very real to him because he has gained them from first-hand experience. We should like to see if, in addition to a knowledge of his subject and how to teach it, he has thought material so rich and abundant that it permeates all his thinking and affects his personal qualities to the everlasting benefit of his students. But we cannot look into this teacher's mind, and so we should like to do the next best thing. We should like to ask him a few important questions. He frequently examines our boy, now we are going to examine him. Here are some of our examination questions:

Does he mingle with men outside of his own profession, and welcome contact with all kinds of men?

Has he gained any first-hand understanding of social problems and governmental problems by actual service to his community—does he carry his fair share of civic burdens?

To what extent has he traveled?

What does he do for recreation—what are his hobbies?

Is he trying to substitute reading and book study for experience? Does his own experience prepare him for reading so that he can widen his horizon and expand his mind by meeting great minds in books? How and what does he read?

Is he seeking culture in a mere acquaintance with things cultural or is he gaining culture without conscious effort from rich and varied experience?

Is he seeking to enrich his experience merely for a purpose or because he has an eager curiosity and interest which compel him to make excursions into experience with a mental welcome to new images and concepts?

These are typical questions in our examination of the teacher. We would not put these questions directly to him, because we do not desire direct answers. We would merely engage him in random conversation. If his mind is stored with rich thought material it will be revealed, unconsciously, we hope, but none the less surely, provided we ourselves have the thought material that enables us to draw it out.

Here and there among engineering teachers, as among all college teachers, there is a mind of exceptional originality and power,—a mind destined for important research. A man with such a mind may make his greatest contribution by concentrating on his work, denying himself many of the richest experiences of life. But most of us are primarily teachers—just plain teachers. We shall render great service if we can be *good* teachers. To be a good teacher we do not need to be exceptionally great in any particular quality, but we do need to be well developed within the whole circumference of experience. Mr. Gano Dunn has said: "The type of man that makes the engineer, fundamentally, is not the type that makes the pure scientist or the research worker. There is something in the make up of the engineer that finds him classified towards that end of the scale described by Shakespeare as the man of 'full habit,' a type which you do not find in the laboratory." To paraphrase this statement of Mr. Dunn's: The type of man that makes the engineering teacher, fundamentally, is not the type that makes the pure scientist or research worker. There is something in the make-up of a good teacher that compels him constantly to seek the enrichment of experience so that through the passing years he gradually grows to the full stature of his potential power and influence.

THE OBJECTIVES OF COURSES IN DRAWING AND DESCRIPTIVE GEOMETRY *

By THOMAS E. FRENCH

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It probably can be safely said that there is no subject in a college curriculum whose objectives and aims and importance and value are so vaguely understood by educators in general as are those of the subject of graphics.

When Count Gaspard Monge introduced his new subject of Descriptive Geometry into the curriculum of the Ecole Polytechnique in 1795, after it had been held so long as a military secret, he probably emphasized to the committee on instruction its practical value in the graphical solution of problems which up to that time had been solved by long analytical methods or laborious empirical constructions, but we may be very sure that he well knew what a powerful subject it would be in training in constructive thinking.

He says in his text, abbreviating in translation, that descriptive geometry has two objects: the *first,* to give the methods of representing on a sheet of paper which has only two dimensions, the shape of a body which has three. The *second,* to recognize from an exact description the form of a body and all the truths about it.

But in his long introduction or "programme" Monge goes much farther in his description of the value of this new science. He attributes the dependence of France on foreign industry to its lack of appreciation of exactness, and prescribes the study of descriptive geometry by all the people as the remedy to make the nation independent, to exercise the intellectual faculties of a great people and contribute to the perfection of the human species. That this high estimate of the subject which he had developed so thoroughly had a great effect on national education in France is evidenced by the fact that from that time to the present descriptive geometry has held a most prominent place both in the secondary schools and the colleges. It is always classed as a branch of mathematics, and in the technical schools is carried much farther than was ever done in this country.

This is equally true of other European countries, as Switzerland, Germany and Sweden, where thorough courses in advanced de-

* A lecture delivered before the Engineering Drawing and Descriptive Geometry Session of the S. P. E. E. Summer School for Engineering Teachers, June 12, 1930.

scriptive geometry are given in all the engineering schools. (Without having counted them, I believe there have been more *descriptives* published in France in the last twenty years than in the United States.)

When brought to this country in 1816 by Colonel Crozet, descriptive geometry came as a military subject. In the first book on it written in English (1821) Crozet tells of its usefulness in machine design, bridge design, roads and canals, ship construction and fortifications, and at the same time recognizes its value in strengthening the imagination, as indicated by the following quotation:

"We are now possessed of new and fruitful methods, which are capable of being applied to all kinds of combinations that circumstances can require, or the mind conceive. We ought, therefore, from their application, to expect the greatest perfection in modern works; and this not only from the facility we acquire in translating our projects into *graphic language,* but still more from the habit which the simplicity of the processes in descriptive geometry gives us of conceiving the forms of bodies, and deducing from their ideal representation the most abstract truths of geometry. In fact, by studying this new science, the mind becomes accustomed to figure to itself lines and surfaces, arranged and combined in every possible manner. This action of the imagination increases its strength and its accuracy, so that it has been said, with truth, that descriptive geometry was the science of the engineer. The remarkable clearness of its operation, its peculiar character of evidence, the faculty which it gives of beholding mentally the moving representation of geometrical figures, cannot fail of being extremely useful in practical mechanics; as the perfection of machines depends principally upon the ease with which we conceive and combine their elements. . . ."

Charles Davies, who succeeded Crozet at West Point, has in his book *Elements of Descriptive Geometry,* published in 1826, a paragraph giving his idea of the importance of the subject:

"The study of the mathematics, whether considered as introductory to its sister science, mechanical philosophy, or as a salutary and invigorating exercise of the mind, is equally worthy of attention. The useful and important results to which it leads, mutual dependence of its parts, and the concise and satisfactory reasoning in the development of its principles, recommend this study, as well to the practical man, who learns only what he can successfully apply, as to the lover of science, who explores all its departments in search of new facts and interesting truths."

His next paragraph, which was quoted by Professor Higbee last year in his *History of Descriptive Geometry,* is of interest in connection with this study of objectives.

"The subject of descriptive geometry, which is treated of in these elements, has not, as yet, been considered in this country as a necessary part either of polite or practical education. It has been taught in the Military Academy since 1817, but has not found its way into other seminaries with a rapidity at all proportionate to its usefulness. The progress of science, like that of truth, is always slow; yet it compensates for its want of velocity in the steadiness of its advancement and the certainty of its success. In France, descriptive geometry is an important element of a scientific education; it is taught in most of the public schools, and is considered indispensable to the architect and engineer. Its intimate connexion with civil engineering and architecture, and the facilities which it affords in all graphic operations, render its acquisition desirable to those who devote themselves to these pursuits."

Church, who succeeded Davies, evidently saw no necessity for writing an argument for a subject required and well established in the curriculum. As you will recall, he merely says in his Preface, in the accurate language that would be expected from a military engineer:

"Without any effort to enlarge or originate, the author has striven to give, with a natural arrangement and in clear and concise language, the elementary principles and propositions of this branch of science, of so much interest to the mathematical student, and so necessary to both the civil and military engineer."

And the opening sentence of his book gives the definition, that perhaps has not been improved upon:

"Descriptive geometry is that branch of Mathematics which has for its object the explanation of the methods of representing by drawings:
First. All geometrical magnitudes.
Second. The solution of problems relating to these magnitudes in space."

Which of course shows descriptive geometry to be the theoretical basis upon which all of our drawing is built.

The quotations from these early books indicate the objectives in the minds of their pioneer authors. It is not necessary to go much further in quoting later authors, either in the barren period after Church or the prolific period of the present century, but one from each of these periods may be mentioned. Perhaps the most condensed definition is in Waldo's abbreviated manual of 1887—"Descriptive geometry gives power to express conceptions and to solve problems in the constructive arts; it also effectively disciplines the geometrical imagination."

Colonel Miller has a vigorous opening in the preface of his little book of 1911—

"Believing that no one study plays a larger part than descriptive geometry in the shaping of the student's mind into the analytic thinking machine necessary to success in any engineering profession, the author has outlined and written the text with this as its chief aim."

Most of the present-day authors in their prefaces emphasize the practical value of the subject. These introductions no doubt tend to give the prospective student a sense of the importance of the subject he is about to study, and perhaps to defend its position in the curriculum. And, indeed, in these days of destructive criticism, a subject must be defended, and be capable of defense, against iconoclastic attacks, and must have more than tradition and precedent to enable it to hold its position.

As technical schools were established, one after another, in this country, their courses in descriptive geometry and drawing were modeled after the French experience and methods. In drawing, skill in execution was the chief objective. This was in the day of the fine line drawing, made to look like a copperplate engraving. Reproduced examples seen by the students were actual engravings either on copper plate or on lithographic stone. Shade lines were universally used and much time was spent in surface shading both in line and in water color. Whole courses were given in laying water color washes, either by the French method of overlaying or by the faster American method of softened tints. Drawings were duplicated by pricking through and later by tracing. With the invention of blueprinting all the fine line requirements and colored sections and shading became obsolete, and these courses were gradually modified or dropped. This change in drawing practice eliminated the necessity for long training for skill in difficult execution, and gave a justifiable reason for reducing the number of hours required. The time thus saved was eagerly taken by other engineering departments to keep up with the advance in engineering practice, and thus the precedent was started of cutting the drawing department's time whenever a new course was added. According to Dr. C. R. Mann's report, the total time allotted to drawing at the Massachusetts Institute of Technology was reduced between 1867 and 1914 from 49 hours to 17 hours. This reduction has continued in the case of some schools to an unjustified minimum.

The limited time allowed for the subject places a correspondingly greater responsibility on the drawing teachers to know their objectives and work to them with no lost motion.

Each year large numbers of high school and preparatory school graduates enter our universities and technical schools to prepare for the various engineering professions. Curricula have been arranged in the attempt to use to the best advantage the four years

of time allotted to undergraduate courses, and the problem of the drawing department is to use its portion of this time to train these young men in knowledge and habits of thought that will serve them in the best way in their life work.

As drawing and descriptive geometry are so closely allied, and in this country are almost universally taught in the same department, they have in this topic been combined as one subject.

In classifying the objectives toward which a drawing department should work, they may be placed in two general divisions, practical and cultural (so-called), although in teaching the subjects there is a constant overlapping, as the practical side well taught is cultural, and the cultural aims are motivated by practical reference.

By *practical* we may be considered to mean the things that an engineer must know in the practice of his profession. He must in the first place be able to make an accurate graphic representation of a structure. An engineer who could not read and write in the graphic language would be classed as professionally illiterate. Monge's two objects then still stand, just as important as when he proposed them in 1795, and we recognize orthographic projection as the foundation of all shape description. But there are degrees in proficiency in language. Although handicapped, a man can get through life with a limited vocabulary and faulty grammar, and some engineers have managed to practice their profession with a comparatively meager knowledge of the graphic language; but the engineer who can handle it fluently has a great advantage. Even if his penmanship, his execution, is poor, the ability to read a drawing accurately and quickly is of great importance. *One of the dangers in teaching this language is that the student may learn to write better than to read.* Training in reading drawings should be given constant attention.

From the practical point of view size description is as important as shape description, although it is perhaps difficult to make the student appreciate that fact. More time than formerly is now being given to the study of dimensioning, with the result that the student not only learns to dimension a drawing properly but he begins early in his course to get an elementary knowledge of different methods of shop production.

Another practical object is the teaching of the value and use of symbols, the idioms and abbreviations of the language. Drawing is often called the universal language, but it still has a good many dialects, although standardization is gradually bringing them together.

The analogy between drawing and written language has been made very often, but the comparison may sometimes give the impression that drawing is a sort of elementary or incomplete form of

communication. On the contrary, drawing is the one language of *exact* expression. Words are only symbols of mental pictures varying with every reader, and not only are they inadequate to describe constructions, but word combinations are so inaccurate and imperfect that the principal business of at least one entire profession, that of law, is to prevent and correct word misinterpretations. We may be thankful that the graphic language has invariable content and is interpretable without the services of another profession.

In the making of drawings there arises the question of the relative importance of the objective of skill. We all agree that the use of the instruments is only incidental in the subject of graphics, although there are too many people who think that teaching drawing is only teaching how to draw. In the early days students became skilful draftsmen, and many of them entered the profession of engineering via the drafting room. While more at the present time choose to go into management, administration and production, or even into sales, rather than into design, training in accuracy and speed is still one of the important secondary objectives. With the professional draftsman the manipulation of instruments becomes habit, leaving his brain free to work on the design. A designer at work on his board, sketching with facile pencil, changing, discarding, improving—thinking on paper—with no conscious thought of the tools with which he is working, furnishes an example of the fluent use of the graphic language. Even with the limited time available I believe it is possible to teach the use of instruments in such a way as to get a good start toward making ordinary drafting operations automatic, with the motor impulses coming from the sub-cortical regions.

Many a student gets his first idea of the meaning of accuracy when he starts in elementary drawing. Continued insistence on accurate execution must eventually improve accuracy of thought, and incidentally train in neatness. Commercially, accuracy is worth very little without the accompaniment of speed, the two together forming skill. As with any other operation requiring coordination there is a wide difference in ability. Students to whom skill comes easily often find subsequent graphical work attractive and enter their profession through the drafting room. Training in skill could be listed as a cultural objective as well as a practical one, since this skill may form the basis of ideals which will be carried over into other skills of manipulation.

The real training in accuracy of thought, however, comes from the subject matter of graphics rather than from careful execution. Drawing and descriptive geometry are exceptional educational subjects for strengthening the power and habit of exact thinking, one

of the most difficult of all habits to fix. There is, perhaps, no other subject in the curriculum so well adapted as is descriptive geometry for training in analytical and synthetical thought, and certainly there is no other subject to compare with it in training the constructive imagination and power of visualization. Descriptive geometry lays a heavy tribute on abstract intelligence.

Developing the ability to think in three dimensions, to visualize clearly in space, a requirement so necessary to the engineer, begins with simple objects in the elementary drawing course, continues with more complicated forms and progresses to combinations of abstract lines, planes and higher surfaces, somewhere along which progress the limit of the ordinary student's imagery, visual or tactual, is usually reached. For the exceptional man, training up to this point may be the means of unfolding a hitherto unknown power of constructive thinking, and enable him to extend it further to the relations of moving parts and invisible currents, even up to the development of genius. The great inventor is a man with an extraordinary power of creative imagination. The words of Benjamin Lamme on the medal of this Society come to mind, "The engineer views hopefully the hitherto unattainable." He views it with the hope and assurance of a trained mind, whose first exercise in logical thinking from the known to the unknown probably came in his college course in descriptive geometry.

Someone has said that it is "the power and habit of observing accurately that marks one of the fundamental differences between the incapable man and the man of power." In drawing there is a fine opportunity to strengthen the ability for accurate observation. Most of the subjects studied train the memory in retaining knowledge, but drawing trains in visual memory for form and proportion.

With these educational objects of developing the constructive imagination, visualizing in space, systematic and logical thinking, accurate observation, and habits of accuracy, neatness and skill, the cultural side of the work of a department of drawing becomes a tremendously important factor in the training of the future engineer, and when to these are added the practical aims included in the science of drawing, the knowledge and skill required in making engineering drawings, the ability to think on paper and to solve problems graphically, the potentialities in these subjects of our topic, it would seem, cannot be equaled by any other fundamental subject in the curricula of engineering education.

The methodology of drawing is complicated and difficult, although it would seem such an easy subject to teach. This is not only on account of the combination of objectives but also because of the great variation in the power of constructive imagination to be found in a group of students having approximately the same meas-

ure of mental capacity. Some have strong powers of visualization, others almost none. In the abstract mathematical sciences requiring pure reasoning ability, imagination is not a necessary aid, it might even sometimes be almost a detriment. Galton, you will remember, in his famous inquiry found a majority of his "men of science" to be devoid of mental imagery. But the engineer, whose profession is to invent, and design, and create form out of matter, must have it, and then must be able to record his ideas in a technical language whose style requirement is perfect clearness.

To develop this mental power in all the members of a class of so widely varying rudimentary ability and carry each one as far as his capacity allows, keeping the upper half spurred to higher endeavor and the lower half encouraged and interested, requires a high order of teaching.

Drawing is not a side line to be carried by an instructor of physics or chemistry. To delegate its direction to the inexperienced or immature is a crime against the student and a detriment to the engineering profession. It should be taught by a specialist trained in knowledge and skill, with a background of drawing board experience and a teaching instinct, who appreciates both the importance and the difficulty of his work and accepts with an earnest enthusiasm the responsibility of training the young minds instrusted to him in a subject of such indispensable value that without it modern engineering could not exist.

The objective of the present session is to analyze and evaluate the aims of this subject and find how best to attain them.

NEW MEMBERS

ADAMS, THOMAS O., Associate Professor of Civil Engineering, University of Utah, Salt Lake City, Utah. R. H. Suttie, H. P. Hammond.

BURGMAN, BASILE D., Assistant Professor of Structural Engineering, Moscow Technical Institute, Moscow, Russia. R. H. Suttie, H. P. Hammond.

DRUMMOND, GARRETT B., Assistant Professor of Mathematics, Oklahoma A. and M. College, Stillwater, Okla. L. L. Patterson, G. G. Gladney.

FISKE, DAVID L., Secretary, The American Society of Refrigerating Engineers, 37 West 39th St., New York City. R. L. Sackett, A. J. Wood.

GOODRICH, EDWIN A., Instructor in Civil Engineering, Lafayette College, Easton, Pa. Geo. F. Roehrig, Joe B. Butler.

HOLLAND, UBERT C., Instructor in Mechanical Engineering, University of Pennsylvania, Philadelphia, Pa. H. C. Berry, John A. Prior.

JONES, WALTER B., Research Professor of Education, University of Pittsburgh, Pittsburgh, Pa. F. L. Bishop, Nell McKenry.

MATHEWS, RALPH T., Instructor in Mechanical Engineering, Duke University Durham, N. Car. Walter E. Farnham, Arthur W. Leighton.

PLUMMER, FRED L., Assistant Professor of Civil Engineering, Case School of Applied Science, Cleveland, Ohio. H. P. Hammond, H. S. Carter.

SCHWARTZ, FRANK L., Instructor in Physical Elements of Engineering, Pratt Institute, Brooklyn, N. Y. F. L. Bishop, Nell McKenry.

SMITH, W. SHERMAN, Assistant Professor of Civil Engineering, University of the City of Toledo, Toledo, Ohio. John N. Eckle, Joe B. Butler.

TRACY, STEPHEN J., Instructor in Mechanical Engineering, University of Pittsburgh, Pittsburgh, Pa. F. L. Bishop, Nell McKenry.

REPORT OF SOCIETY DELEGATES TO THE WORLD ENGINEERING CONGRESS, TOKYO, JAPAN

August 6, 1930.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION,
University of Pittsburgh,
Pittsburgh, Pa.

Attention: Professor F. L. Bishop, Secretary.

Gentlemen: President Kimball of the Society for the Promotion of Engineering Education, appointed the undersigned delegates to represent this organization at the World Engineering Congress held in Tokio.

We were all so fortunate as to secure accomodations on the official steamers "President Jackson or "Korea Maru" sailing from San Francisco on October 10, 1929, which carried the majority of the American delegates to the Congress. Besides being delegates from the Society for the Promotion of Engineering Education, each of us was also a representative of other educational institutions, engineering societies or scientific societies.

Besides being under the direction and control of the Japanese Engineering Societies, the World Engineering Congress and its associate, the World Power Conference, were made official functions of the Japanese Government and the delegates were shown great hospitality and kindness. The Americans were particularly singled out for hospitality, although this was not done to the injury of the delegates from other countries who came from all the important nations of the world.

Your representatives were called upon to preside at one or more sectional sessions of the Congress and were called upon for various official Congress duties.

The Congress was a very dignified affair with delegates from many of the greatest educational institutions of the world in addition to the delegates from governments and engineering societies.

Sincerely yours,

P. M. LINCOLN,
JOSEPH W. ROE,
DUGALD C. JACKSON.

BOOK REVIEWS

Sewerage and Sewage Disposal. METCALF AND EDDY. McGraw-Hill Publishing Co. 743 pages. Second edition.

The second edition of this well-known textbook has been materially enlarged and rearranged. The usefulness of the work from the engineer's viewpoint with the many charts, tables and detailed drawings, is unimpaired. The enlargement has been along the lines of basic principles of hydraulics, sewage and sludge treatment.

The omission of the table of the definition of terms would appear of doubtful wisdom but is comparatively unimportant. The addition of a liberal assortment of problems at the end of nearly every chapter is an outstanding improvement from the teacher's view point.

The chapter "Hydraulics of Sewers" has been rewritten with comprehensive mathematical analyses of the various phases of hydraulics that pertain to sewerage systems.

The treatment of the design of separate and storm sewers is much more complete and an entire chapter is devoted to it.

A chapter "Loads on Sewers" has been added. This chapter contains the results of the experimental and theoretical investigations of Marston, Anderson, Terzaghi and Mohr on earth pressures as applied to sewers. The selection of the shape of sewer section is considered in relation to construction, available space, and physical properties of sewers in an appropriate chapter on "Pipe and Masonry Sewers."

The chapter "Characteristics and Behavior of Sewage" (Chemical and Biological) has been improved by discussions of the meanings and relative values of chemical and biological determinations. This chapter is especially valuable to the student or engineer whose chemical training has been limited. The theory of Hydrogen-ion concentration is clearly summarized. Much valuable material has been added to the chapter "Disposal by Dilution," such as the Legal Aspects of Sewage Disposal, Oxygen Balance and Oxygen Sag, and the discussion of the stages of self-purification is more complete.

A chapter "Principles of Sewage Treatment" is added. This is of special interest to the sanitarian. It is an exposition of Hazen's Theory and Stoke's Law on Sedimentation and the chemical reactions of flocculation, sludge digestion and disinfection. Oxidation, filtration and activated sludge treatment is also explained.

The treatment of sewage filters is clarified by grouping the general principles of all filters in one chapter. This saves the repetition of separate discussions of each type in different chapters.

Summarizing, the work is notable as the result of the coördinated efforts of a highly reputable group of engineers assisted by engineering teachers drawing freely from outside sources of information. The first edition was presented from an engineer's point of view. The revised edition is much better suited to teaching purposes in that the arrangement of the material in the chapters causes a more logical sequence in the presentation of the basic principles, many additional and valuable fundamental principles are presented, and a much more liberal assortment of problems at the end of nearly every chapter greatly increases the value of the book for teaching purposes.

teaching purposes.

L. W. McI.

Applied Mechanics. Alfred P. Poorman, A.B., C.E. 3d edition. McGraw Hill Book Company. 297 pages, 17 chapters.

This 3d edition of "Applied Mechanics" still maintains the high standards established by the two previous editions.

The text affords an excellent opportunity for the student to display plenty of common sense, the power to visualize and the ability to think clearly, especially in that part on statics where formulae are few and far between.

There is a wealth of good problems and examples which bring out the fundamental principles and also plenty that test the ability of the best student.

By supplying answers to all problems it affords the student an opportunity of checking his result with that supplied by the author.

By doing so the student generally discovers his error, whether in thought or execution, thereby saving valuable classroom time.

The introduction of the principles of work and energy in the early chapters on kinetics is an added feature of this edition.

The text is admirably suited to a five semester credit course, although with certain omissions may be used equally well in an abbreviated course.

R. F. E.

COLLEGE NOTES

University of Southern California.—Nathan C. Clark has been appointed instructor in electrical engineering in the College of Engineering of the University of Southern California.

Mr. Clark will assist in the general courses in electrical engineering and will have charge, with Professor Philip S. Biegler, head of the department, of the development of high frequency and radio work.

Stevens Institute of Technology.—The curriculum of Stevens Institute of Technology for the academic year 1930–1931 will include for the first time in the sixty year history of the college courses for graduate students. Stevens has heretofore offered a general unspecialized course in engineering and has given only the undergraduate degree in course. Since the inauguration of President Harvey N. Davis a Faculty Committee has been investigating the field of graduate instruction. Following the recommendation of this committee the Trustees and Faculty have approved a program of graduate courses leading to the degree of Master of Science.

Graduate instruction is given during the day in the fields of Electrical, Mechanical and Civil Engineering and in Business Administration. Research projects in the Properties of Steam, Smoke Abatement and the measurement of Engineering Aptitudes are now in progress.

EDITORIAL

C. FRANCIS HARDING

Vice-President of the Society

The Society for the Promotion of Engineering Education is a powerful organ underlying the industrial growth of America. If one adopts the conservative estimate that engineering education has been improved twenty-five per cent in efficiency during the past generation as the result of the activities of this society, who will venture to evaluate the industrial and economic growth of the country dependent thereon? What was your share therein?

But that is a matter of history! What of the future? What will our 1931 class of engineers produce before 1951? It gives us pause to contemplate *their potency* and *our responsibility*. What of research, of invention, in their relation to international communication and transportation; to peace; to war; in 1951? May we not well express the hope with L. A. Hawkins in his admirable article upon "Engineering Development and Research" from the following quotation: "Is a Faraday as impossible to produce by education as a Shakespeare, a J. J. Thompson as a Robert Browning? I do not know. . . . I wish only to express the hope that the growth of research work in the colleges and universities will lead to a more general appreciation of its requirements, a quicker perception of real research ability in students, and a better opportunity to encourage and develop that ability.*"

Just as the slogan of the 1928 convention was "Industrial Cooperation" and that at Montreal was "Industrial Leadership," may we not have next June as the keynote of the convention: "Research and Engineering Education?"

* *General Electric Review*, February, 1929.

SOME REACTIONS ON THE MONTREAL MEETING, S. P. E. E.

The most impressive characteristic of an S. P. E. E. meeting is the tolerance which the members quite universally exhibit toward quite individualistic points of view. At the close of the first day at Montreal I had voted the meeting one of the best in the recent history of the Society. The sessions of the second and third days were nearer the level of the commonplace. In Boston the 1912 meeting had devoted its attention very largely to Management: That seems to have been a little too much for us. But, Elliott D. Smith's discussion of the problems of teaching Management was a distinct advance along this line. His ideas approach nearest to a Psychology which has come down to earth of anything I have ever sampled. His method has in it the solution of no end of problems in engineering education. That Elliott D. Smith's discussion on Thursday evening was a hard one for the membership of the Society to assimilate but, on that very account, interesting and probably epoch-making.

Excellent arrangements, well prepared papers, pertinent discussions, and a spirit of good fellowship, were the outstanding features of the recent S. P. E. E. meeting in Montreal. In addition there was statesman-like preparation to deal with forthcoming major problems as shown by the move to draw closer to the founder engineering societies.

The chief value of any S. P. E. E. meeting is the opportunity it affords for personal contacts and informal comparing of experiences. It was a fine thing to be able to do this with our Canadian cousins at Montreal.

Place and circumstances: Everybody was glad to go to Montreal and appreciated the comfort and courtesy of our entertainment. Program: Plenty of good material well presented. Spare time: Not enough. There should be a definite time in the program to see things of engineering interest in the institutions and in the city. General discussion: The appointed speakers occupied, by arrangement, so large a part of the time in each session that there was little or no opportunity for general discussion. A serious loss.

I am personally more interested in the small sectional meetings, rather than in the general meetings. In my opinion it is a great

waste of time and energy to travel hundreds of miles to listen to some talk which might equally well be printed and read at leisure. Personal contacts on the other hand I find most stimulating and helpful and naturally points are brought out and discussed in a way that it would not be possible in a paper.

Another thing, that I speak of with some diffidence because I may be entirely misinformed, was the apparently cut and dried manner of the elections. It appeared to me that a small group were in complete control of the Society. As I say, I may be entirely wrong as this is merely a hasty reflection and I give it to you for what it is worth. I do not wish to imply that the Society has in any way been mismanaged. It merely struck me that the average member was completely lost and had little or no say regarding the policy of the Society.

The Montreal meeting was a most profitable one from the viewpoint of the papers submitted. The epitomization of faculty relationships gave everyone a mental "filly" which must provoke much thought and some results.

The meeting was particularly well organized and the hospitality afforded on the part of McGill University thoroughly appreciated. Comments were numerous regarding the courtesy and attention extended to the ladies. One particularly interesting fact developed from the summary of the study of Engineering Education presented by Dean Bishop, was the almost universal rearrangement of curricula to conform with recommended changes in credit hours or work and in the general relation between technical and non-technical subjects. The advance and proposed suggested improvements in the teaching of English to engineers was noteworthy and the conference on this subject most helpful.

I have been a constant reader of the Journal of the S. P. E. E. for the last fifteen years, but the annual meeting of the Society with the personal contact and exchange of ideas at first hand with representatives of other institutions is certainly much more gratifying and instructive.

Too much emphasis placed upon training for the trades instead of engineering as a profession. The banquet was a great success.

In the first place, I would like to tell you that I derive the greatest enjoyment from the S. P. E. E. meetings. I look forward to

these gatherings with the utmost pleasure. Now the Montreal meeting was very enjoyable, but as I believe I have written you in the past, there were probably too many papers and not enough time for social gatherings. Meeting our colleagues is one of the agreeable features of these meetings. But don't think I am criticizing you or the Council, because I realize the importance of the papers presented. If we could concentrate our efforts and discussions on one or possibly two problems which have been studied by the Board and permit more time for social visiting, I would like it better. May be, however, I am in the minority.

I enjoyed the hospitality of McGill University and l'Ecole Polytechnique; and received the usual inspiration from the renewal of friendly contacts with S. P. E. E. members. The papers that were offered were good; but the program was too full to permit the desired discussion.

The Montreal meeting was the best of the sort that I have ever attended. There was the usual good fellowship which characterizes the S. P. E. E., and every part of the program well worth while.

Briefly I feel that more time should be given to group discussions of the round table order.

A good program; splendidly housed and handled.

Feel that the Montreal meeting was very much worth while.

The meeting of the Section on Electrical Engineering at Montreal was the most enthusiastic one we have so far held. The talks by Mr. Smith of Yale and Mr. Lewisohn impressed me particularly. I can't understand why such a large group of men will come all the way to Montreal and then not go to hear these two men. What they had to say affects engineering education vitally, yet the attendance was entirely too small. The compilation by the Secretary of the data on engineering schools, obtained by the Office of Education, I found very valuable.

During the past few years the S. P. E. E. has exhibited a new vitality. The meeting at Montreal reflected this change. The cause we believe can directly be traced to the self investigation of engineering education and to the summer conferences for engineering teachers both of which have contributed to the Society a feeling of substantial accomplishment and future outlook.

I especially enjoyed the meetings on various subjects held on the first day of the Montreal convention. I would like to suggest that some of these conferences on special subjects be scheduled so as to permit one to attend more than one conference. The entire convention was so splendidly arranged and carried out that any other comment is necessarily congratulatory.

For me the Montreal meeting was an outstanding success. The real interest in educational matters, reflected by the papers and committee reports presented, awakened a new confidence in the work of the Society. I am proud of its outstanding accomplishments in the field of educational research.

Outstanding feature was a two-hour visit with Professor E. G. Burr, Department of Electrical Engineering, McGill University. He talked about the Ottawa River power developments and reminisced about Alexander Gray.

While I enjoyed the Montreal meeting, I am afraid that outside of the annual dinner and possibly one or two papers it did not leave many lasting impressions.

I was very much interested in the Montreal meeting, although the material was more general than usual. It seems to me that it must need be so as the summer schools and different groups will take the place to a certain extent of a detailed program. I for one was very well satisfied with the meeting.

From the standpoint of program subjects discussed, speakers, meeting rooms, etc., I feel the Montreal meeting left nothing to be desired. As valuable as the meetings were the pleasant associations and the cordial good fellowship of all in attendance were alone well worth the trip. As hosts the McGill University set a high standard of hospitality. The secret of the success of the whole convention is not hard for me to know.

I was very much impressed with the meeting in every respect the regular session program was very splendid and I do not see how the social functions could have been improved. I consider it a very successful and profitable meeting and hope that I may have the pleasure of attending the one scheduled at Purdue next year.

The Montreal meeting impressed me most favorably. Each institution visited by the convention has its own local environment, traditions and pedagogical methods that contribute greatly to the

values received by regular attendants. The S. P. E. E. is now a most helpful and powerful factor not only in the pedagogical but in the engineering and industrial world.

The meeting in Montreal was interesting and instructive. A great deal of ground was covered in the time available, but a lighter program would be more enjoyable and would make it possible to have more discussion of the papers.

I have attended every meeting of the S. P. E. E. over a period of many years and have always enjoyed and profited by every one of the programs. It seems to me that the Montreal meeting will always stand out as one of the best ever held. There were many good papers presented and addresses delivered. To my mind the two outstanding items on the program were: first, the address of welcome by Sir Arthur Currie, and the second, the presidential address by General Rees. Each of these addresses contained much constructive material. The presentation of the Lamme medal to Dr. Charles F. Scott was most impressive and will long be remembered as one of the bright spots of the Montreal meeting. The recipient was more than worthy of the great honor bestowed upon him.

Meetings of the S. P. E. E. which are held in centers where it is impossible to be grouped in close contact with each other are not as successful as meetings held in smaller communities. It is my opinion that programs of the kind which were presented at the Montreal meeting will fail to hold the interest of engineering teachers in the S. P. E. E. Personally, I feel the need and I have heard others express a similar idea, namely, that there is the need for a Renaissance in the Society so far as its general conventions are concerned.

I was much interested in the group meetings and would like to attend more of them, but wish they were scattered so that I could attend more than one subject. I thought that most of the Council business might have been done by correspondence or committees, making the Council meetings less arduous and more important.

Good in every particular but there was not time enough for the program as set up. General Rees set a pace that others will have difficulty in matching, and he deserves much credit for the success of the meeting. These sessions should not be carried over into Saturday afternoon. It was unfortunate that so many missed the excellent program presented at that time.

I profited much by the Montreal meeting and enjoyed greatly the hospitality of our Canadian friends at McGill and l'Ecole Polytechnique. The efforts of President Rees, Secretary Bishop, and our hosts to provide a worth while and stimulating program were most successful and I am sure were appreciated by all those present.

The Montreal meeting of the S. P. E. E. was an earnest meeting of educators in the discussion of their problems and like its predecessors will prove fruitful by adding to the spirit of coöperation amongst the engineering schools and their faculties, and between the engineering schools and the industries. The choice of the recipient on whom the Lamme Medal was awarded and the fact that suitable representatives are still active amongst us. If the change in the name of the Society, which was recommended by the Council, is put into effect, this also probably will have a desirable influence.

The Montreal meeting was interesting and successful, particularly in the fact that we were able to see and learn of the Canadian methods in education and research quite completely. As usual the program was crowded but I am not certain that it would have been as successful if the opposite effect had been produced, namely, too contracted a program. We should have more discussions in the S. P. E. E. meetings.

I consider the Montreal meeting one of the most interesting meetings that it has ever been my pleasure to attend in the past twenty years. Especially was this so because of the hospitality shown, interesting papers presented and the new acquaintances made of teachers who do not usually attend meetings in other parts of the country. I wish to congratulate you upon the smoothness with which this meeting was run, and particularly upon the program presented at the annual banquet—such programs are of real value.

A less extended programme with a little more time available for discussions might be an improvement.

A very interesting and instructive conference, conducted efficiently and with dispatch. I believe, however, the value of these conferences could be increased if it were possible to schedule the group meetings at different times. Many of us are interested in several phases of the educational program but because of conflict were able to attend but one group.

The new division on the Coöperative Plan of Education held its first session at the Montreal meeting. There were over fifty in

attendance including most of the plant representatives who had come to Montreal. The live interest which developed in discussion indicated that this division is of importance and should be given two half days instead of one. The whole Montreal meeting was a success from the writer's point of view.

Meetings at Montreal could have been held in two days. Would like to see a section on Machine Design and Materials of Engineering again.

The point that impressed me most regarding the meeting and its program was the amount of attention paid to discussions of human relations. Such a program could hardly have been carried out a few years ago because engineers had thought so little of personnel relations but continued to lay stress upon materials and methods. It is a very significant thing I believe that the engineering profession is taking up these problems and it will surely increase the prestige of the profession.

The program in Montreal this year was very interesting and instructive. I was especially interested in Professor Smith's presentation of "Training Engineers to Handle Men."

The Montreal convention I found helpful, instructive, and broadening. The papers were good and on pertinent subjects but opportunity for discussion was too restricted. The idea of one social period (afternoon or evening) each day is to be commended. An excursion might be worked in another time. Sessions after the banquet seem suggestive of an anti-climax.

International character of meeting particularly pleasant. General programs full of inspiration. Would like to see section meetings scattered through a longer period so that one might attend meetings of more than one section even though section meetings might conflict with some of the general meetings. Would even eliminate some of general meetings if necessary.

The Montreal meeting was to me both pleasant and profitable. However, the time of the meetings was too short for anything like a full discussion of the papers. This was particularly true of the sectional meetings. This condition indicates a high degree of interest in the work of the Society.

I found the Montreal sessions very interesting and instructive.

Unusually delightful hosts, an efficient and practical local committee, an interesting and well balanced program, and an effective and dignified presiding officer all combined in making the Montreal meeting a most happy reunion for those interested in engineering education.

Thoroughly enjoyed the Montreal meeting, both the papers and the friendly hospitality of our hosts. It was my first visit to McGill, of whose splendid record I was well aware, which made the sessions particularly interesting. The only suggestion I can offer for another year is that more time be allowed for discussion and papers of a controversial type be solicited. I do not believe enough members take part in the proceedings.

I am sure all will testify to the meaty program and the warm hospitality of McGill University. In addition I want to express appreciation for the atmosphere of open-minded interest in our new problems in teaching. There was a friendly give and take during informal discussion more enjoyable than any I have previously experienced.

The technical sessions of the Montreal convention were very interesting. Taken all in all, the trip to Montreal was worth while to me. I was very much disappointed to find that the A. I. E. E. and S. P. E. E. conventions overlapped so that I had to miss important parts of each. I hope that this may be avoided in the future.

The Montreal meeting was worth a much larger attendance than it received. The numbers that seemed outstanding to the writer were the paper by Professor Smith, and President Rees' presidential address. The latter was a forceful challenge to the engineering profession which will bear repeated reading. Very probably it would have escaped my attention had I not been there.

The unsatisfactory feature of this meeting, as of others, was the tendency to crowd the program. Less papers per session would have allowed greater freedom of discussion. When the chairman is fighting for time, the ablest discussion leaders refrain from taking part.

In the session devoted to group conferences, it usually happens that meetings on related subjects are held simultaneously. At Montreal, for example, one was unable to attend both the sessions on coöperative engineering and industrial engineering, or both the sessions on machine design and mechanics. It was a case of choose one or the other. This could be avoided in the future by giving an entire day to these conferences.

The Montreal meeting seemed doubly enjoyable because of the scenic delights of the water trip down the St. Lawrence valley and the historic interests of the city itself. At the risk of being misunderstood, it is wished that all our meeting could equally combine vacation with business.

The vigor and interest of the sectional conferences with their intimate contacts and stimulating exchange of ideas and practices was one of the most gratifying experiences of the conference.

The opening session in Moyse Hall colored by such personalities as Aurelien Boyer, Sir Arthur Currie and General R. I. Rees, and vitalized particularly by the presidential address upon "Engineering Leadership" I am sure gave a great inspiration to all in attendance and left a sense of the responsibility of the engineering educator that should stimulate the constructive expression of many improvements and accomplishments in education.

I think perhaps one of the most pleasing moments of the conference was the presentation of the Lamme medal to Dr. Charles F. Scott, who was the first recipient of the medal personally to receive it at the annual banquet where the award is announced. Dr. Scott's personality and manner, together with his most unusually accomplishments and contributions, gave one a great sense of satisfaction and agreement with the committee's choice.

I have no criticisms to make of the meeting. I enjoyed all the meetings that I attended and I was especially pleased with the cordial entertainment accorded us by McGill University and by l'Ecole Polytechnique.

It seems to me that the S. P. E. E. has acquired sufficient importance to manage its own affairs. So far as the importance in engineering education is concerned, I believe that this organization should take the lead. By that I do not mean that it should undertake projects that would be antagonistic to other educational organizations, but I do believe that in such matters as the sponsoring of summer schools for the benefit of teachers in engineering schools, its officers should feel that they are vested with full authority. In the section devoted to mathematics, it seems to me that there was a tendency to over emphasize very advanced mathematics as compared with mathematics that is taught to engineering students, even in our best technical schools. Surely we want to keep alive the spirit of research for without that the teacher becomes a mere automaton. On the other hand it would be profitable, I think, for some specific attention to be paid to the importance of teaching mathematics in our schools of technology—not only by a better

presentation of the subject, but by investigation on the part of the teachers relating specifically to the adaptation of the content of their courses to the practical use that will be made of the subject by engineers. This applies to the work in elementary mathematics during the first year, to the courses in Calculus which follow and, most of all, in my opinion, to the particular courses in Differential Equations that will be used in a practical way by engineers.

The address of President Rees was thoughtful and helpful. Coming from a representative of "big business" it was encouraging at the same time that it emphasized the importance of the essential factors in the training of young men for engineering and industry. The several addresses on the teacher and his possible influence on his students, his fellow teachers, and on society were all forceful and timely. The social arrangements made by the Montreal institutes were admirable and added much to the comfort and enjoyment of a very successful convention.

My reactions on the Montreal meeting were similar to those experiences at the National Societies—I find it impossible to be in two places at the same time. Otherwise, I think that on the whole they were successful.

Shorter programs and more time for discussion.

Aeronautic education is sensibly engineering and should be so interpreted. That aeronautics is here to stay is admitted, and is expected to occupy a prominent place, certainly a front seat for many a year, until some greater discovery of humanitarian benefit displaces it.

My reaction to the Montreal meeting is in the nature of a suggestion. There was held in St. Louis last spring and at the city holding the National Air Show each year in the future a meeting on Aeronautic Education. This meeting was sponsored by the Aeronautic Chamber of Commerce, through its educational committee. Could the S. P. E. E. not rightfully assume this to be one of their activities as a Sectional Meeting on Aeronautics and coöperating with the Aeronautic Chamber of Commerce and such other agencies as may have interest therein, to make these Aeronautics meetings mean something far above what they do to-day and to guide and assist those offering courses in Aeronautics? As a member of the Education Committee of the Chamber the writer would be happy to place such matter before the Chamber provided the S. P. E. E. can see its way clear to assume this magnificent opportunity.

The convention was delightfully entertained by McGill University and l'Ecole Polytechnique. Although somewhat crowded, the program, clustered about an important theme, was substantial and stimulating. It may be remarked also that the last session was one of the best.

In my opinion the Montreal meeting was very successful. The programs were interesting, the entertainment and other details were well taken care of by the local committee. See you at Purdue next June.

The following appear to me to be the outstanding reactions of the Montreal meeting as interpreted from the papers and discussions presented:

1. The increasing realization of the vital importance of the personality and individuality of the teacher as a valuable function in Engineering Education.
2. The further emphasis of the value of downright fundamentals, with curricula stripped of many of the "side line" subjects which have been prevalent in recent years.
3. The inspiration which can be derived by students from teachers who are *real* men of high ideals and who are *real* engineers closely in touch with the affairs of the country.

The Coöperative College session was unquestionably the best yet and augers well for the affiliation with the S. P. E. E.

Very enjoyable meeting from all viewpoints. Excellent program. Delightful hospitality. Interesting Canadian atmosphere.

The single suggestion that I have is that the devisional sessions be **not** held simultaneously. At least ten members came to me and stated they wanted to attend the Machine Design meeting but for one good reason or another they had to attend other sessions. Likewise, some who attended the Machine Design session would also have liked to attend other sessions.

T-SQUARE PAGE

DIVISION OF ENGINEERING DRAWING
ORGANIZATION AND WORK

Executive Committee

Thos. E. French, Chairman, Ohio State Univ., Columbus, Ohio; term expires, 1931.
R. P. Hoelscher, Sec'y., Univ. of Illinois, Urbana, Ill.; term expires, 1931.
William G. Smith, Northwestern Univ., Evanston, Ill.; term expires, 1931.
W. E. Farnham, Tufts College, Tufts College, Mass.; term expires, 1935.
F. G. Higbee, Univ. of Iowa, Iowa City, Iowa; term expires, 1933.
H. H. Jordan, Univ. of Illinois, Urbana, Ill.; term expires, 1931.

Committee on Engineering Drawing

A study of and a report on the material presented at the 1930 summer session relating to the teaching and content of engineering drawing courses.
H. M. McCully, Chairman, Carnegie Inst. of Tech., Pittsburgh, Pa.
C. L. Svensen, Texas Technological College, Lubbock, Texas.
John M. Russ, Ohio State Univ., Columbus, Ohio.
F. DeR. Furman, Stevens Inst. of Tech., Hoboken, N. J.
G. C. Anthony, St. Louis, Missouri.

Committee on Descriptive Geometry

A study of and a report on the material presented at the 1930 summer session relating to the teaching and content of descriptive geometry courses.
W. G. Smith, Chairman, Northwestern Univ., Evanston, Ill.
F. M. Porter, Univ. of Illinois, Urbana, Ill.
A. V. Millar, Univ. of Wisconsin, Madison, Wis.
Geo. J. Hood, Univ. of Kansas, Lawrence, Kans.
One Member to be selected to replace Chas. W. Thomas, deceased.

Committee on Research

A study of and a report on problems for research in fields of engineering drawing and related subjects including the teaching of these subjects.
C. V. Mann, Chairman, Univ. of Missouri, Rolla, Missouri.
H. H. Jordan, Univ. of Illinois, Urbana, Illinois.
Chas. H. Schumann, Jr., Columbia Univ., New York City.
H. W. Miller, Univ. of Michigan, Ann Arbor, Mich.
H. B. Langille, Univ. of California, Berkeley, Cal.

Committee on Summer Sessions

To act as advisory editors in publishing the material presented at the 1930 summer session on engineering drawing.
F. G. Higbee, Chairman, State Univ. of Iowa, Iowa City, Iowa.
W. E. Farnham, Tufts College, Tufts College, Mass.
F. M. Warner, Univ. of Washington, Seattle, Wash.

Committee on Drafting Instruments

To compile a report on drafting instruments together with specifications for their manufacture.

F. M. Jones,
J. L. Hodge,
W. F. Stone,
G. H. Frey,
T. M. Brown.

In June, 1929, the Society for the Promotion of Engineering Education appointed a Committee on Instruction in Industrial Relations. After careful investigation, the committee came to the conclusion that the subject was of such importance that a thorough study of the possibilities, aims and methods of teaching engineering students to manage men should be made during the year and the results of this study submitted to the 1930 meeting of the Society at Montreal in June.

To carry out this purpose the committee elected to its membership Professor Elliott Dunlap Smith and requested him to head this study and to put the conclusions reached in form for presentation. A condensed statement of the results of this study has been prepared to present the fundamentals of the problem for deans of engineering schools and others broadly interested. This has been supplemented by a fuller statement of methods for the use of teachers.

These statements are herewith presented to the Society as the special report of its Committee on Instruction in Industrial Relations.

R. L. SACKETT, *Chairman*,
F. E. AYER,
J. W. HALLOCK,
D. S. KIMBALL,
S. A. LEWISOHN,
JOSEPH ROE,
E. D. SMITH,
J. E. WALTERS,
F. W. WILLARD.
R. I. REES, *ex officio*.

May 10, 1930.

CAN THE ENGINEERING STUDENT BE TAUGHT TO MANAGE MEN?

Special Report of the Committee on Instruction in Industrial Relations.
Prepared by Elliott Dunlap Smith, Yale University.

Success as an engineer is more and more calling for executive as well as technical ability. Over three-fourths of all engineers, the Wickenden report shows, go into administrative work and must manage men. Even engineers who concentrate on design or research must be able to deal effectively with superiors, associates, and usually subordinates. Because of this there is a growing demand that engineering schools provide some direct preparation for this important aspect of engineering work.

What then is it essential to provide? And what is it possible to provide in the limited time which can be taken from other engineering education? As few engineers ever become personnel or employment managers, it is hardly warranted to ask them to turn aside from the study of their own profession to acquire proficiency in the technique of another. Moreover, ability to deal with or manage men is an intangible and subtle attribute. This raises the question of whether it can be taught at all. Are not managers born and not made? And in so far as skill in the management of men can be acquired, must it not be acquired from experience rather than from instruction?

Aptitude for acquiring skill in human management, as in other fields, unquestionably depends largely on deep-seated traits. These traits, however, are of relatively little value unless they are developed. It is as unsound to expect executive aptitude to ripen into mature executive ability without training as it is to expect scientific aptitude and ingenuity to develop untaught into engineering skill. While no instruction can replace actual experience in learning to deal effectively with human nature, experience, here as elsewhere, favors the mind which is prepared.

There are two characteristics of experience that make it

important for the student to be fully prepared before matriculating in its school. In the first place, experience is haphazard, not systematic, in its lessons. Even where a company definitely undertakes to provide the young engineers in its employ with developing experience, actual personnel experience cannot be systematically controlled. A company cannot have a strike, or even have a worker lose his temper, for example, at the time most desirable for educational purposes. Much that is educationally vital in experience with human nature is prohibitively expensive. Unless a young engineer has a systematic understanding of this subject and can read an orderly arrangement into the lessons of personnel experience, the assimilation into usable form of the confused medley of experiences which he encounters is a baffling problem. In their infinite variety and apparent inconsistencies, the interrelation of the lessons of experience is lost sight of and, as with all hit or miss methods, progress is costly and slow.

In the second place, experience with human relations rarely makes clear the errors for which it has exacted punishment. Unless a young engineer has been taught in school the fundamental characteristics of human nature and the fundamental problems of human contacts and industrial relations, he is likely to miss the lessons of such experience altogether. Industrial situations are so complicated and human contacts so subtle that it is difficult to discover just what it was in any situation which turned the scale on the side of success or of failure. Often when serious consequences have followed from some failure in management of men, even seasoned executives have overlooked this failure and sought the cause exclusively in equipment or in process, or have seen it in the assumed fault of the employees or of "the other fellow." The very complexity and subtlety of problems of human relations makes it especially important for the student to be prepared adequately to learn the lessons of experience in regard to them.

The danger of overlooking the human aspects of the lessons of experience is especially great with young engineers.

They have been trained to be precise in the mathematical sense. In school they have had their attention directed primarily upon the material aspects of industry. In their early years at work, their tasks are usually confined to problems of materials, mechanisms and process, the human aspects of which are not emphasized nor clearly apparent. Unless they have been made aware of the personnel aspects of their work by adequate training while in school, young engineers are likely to continue for years without deriving from their experience increased capacity to deal with or to manage men. Then, when they later attain positions of executive responsibility, or when the carrying forward of their research or developments calls for the enlisting effective support or cooperation, they find themselves ill equipped. It is because of this situation that outstanding business executives are uniting in urging engineering schools to take measures better to prepare all technical students to handle personnel problems.

What then can engineering schools do to provide this important preparation? Fortunately, out of the mass of accumulated experience in human contacts and industrial relations, underlying principles and tested practices are gradually being evolved. Especially through the application of psychology to its problems, the management of human relations in industry is rapidly becoming an applied empirical science. Hence, although in the field of human contacts more than any other, it is impossible to reduce management to the mere manipulation of precise measures, the engineer who has a sound understanding of the experience of the past—of the situations which have arisen, of the measures which have been taken, of the results which have followed and of the principles underlying them—will have a large advantage over those engineers whose background is confined to their own necessarily narrow and haphazard experience. Thus, although a mastery of the techniques of the industrial engineer or the personnel manager is properly confined to courses for students designing to specialize in these fields, a sound understanding of the underlying experience and principles of

human relationships in industry is of value to all engineers. Such a background can be adequately provided only through a course dealing directly with this subject.

The evasiveness of the human factors in the lessons of experience, and the tendency of engineering training and work to divert attention from them, makes it outstandingly important that this background be not merely an academic one. In human relations men wisely distrust the "mere theorist." With so subtle things as human contacts and industrial relations: theories, information, or practices which are not assimilated by application to actual situations are unlikely to be of substantial value and may even be dangers.

In considering the addition of courses on human relations in industry to the curriculum of engineering schools, these fundamental purposes should never be lost sight of. In engineering schools we are not making personnel managers and we cannot make finished executives. Our aim is to equip engineering students to learn from experience how to deal with and how to manage men. While it is important that they gain an understanding of present-day industrial relations practices and experience, it is far more important that they develop effective attitudes and methods.

With such an objective it is obvious that a satisfactory course cannot be transplanted ready-made from the field of professional personnel management, nor can the standard methods of technical training be employed without adaptation. What is essential in subject matter is that the students be systematically exposed to situations and problems which comprehend the principal sorts of personnel experience an engineer or executive will encounter in his work, and that they be given sufficient background to be able to comprehend these problems as part of an orderly understanding of human relations in industry. What is essential in method is that the student be brought to think independently but systematically and incisively about these problems, and to recognize in them their subtle human elements.

To fulfill these conditions the best type of course will con-

sist primarily neither of lectures nor recitations, but of discussion and actual handling of typical personnel situations. These situations should involve genuine problems which the students will recognize as real, and enter into seriously. They should be related as far as possible to the student's engineering work so that he will be brought to see the personnel aspects of the work in which he is actually engaged at the time. These situations should be carefully arranged so as to involve in orderly sequence the main types of personnel problems which the student is likely to encounter as an engineer and as an executive, for it is just such an arrangement that actual experience fails to provide. Whenever the limitations of class instruction permit, the student should be required to deal with these situations by action, not merely by discussion. In all cases the instructor should insist that the situations be analyzed and conclusions arrived at by an orderly method of approach. The background of fundamental principles, tested practices, and industrial experience are best provided incidentally to the study and discussion of the situations, thus being learned in relation to the handling of actual problems as material which has grown out of actual experience and is capable of practical use.

We attach to this report suggestions as to the teaching of such a course. The teaching of the management of human contacts and relations by this method involves more mature and qualified leadership than is required for the typical text-lecture-recitation course. It is not possible for the instructor to lean heavily on the text, for when discussion is free he must know the field thoroughly from every direction in which discussion may turn. On this account, we have also given suggestions for a lecture and recitation course. We wish to emphasize, however, that what is essential is the development of habits in the student which will render him sensitive to the human aspects of the situations with which he will later come in contact and will cause him to approach these situations systematically and effectively. This can only be accomplished through a subject matter related to his own present and fu-

ture problems, through a background of principles that the student recognizes as growing out of actual experience, through methods that cause him to think and act—not merely to remember and repeat. Whatever form of instruction is employed, these fundamental purposes should be kept in mind.*

In whatever branch of engineering a student persues, the development of ability to deal with men will be of primary value. Such a course as we have described is thus part of a general engineering education.

SUGGESTIONS FOR TEACHERS OF COURSES IN MANAGING AND DEALING WITH MEN

CONTENTS

No methods can solve the problem of teaching engineers to manage men. Such teaching even more than the teaching of technical subjects, is an art that can never be reduced to rules. Good reading material, good problems, good examination questions, good arrangement and good principles of conducting classes, all are important. But after all, these are but

* *Note:* The importance of these fundamental purposes, even in teaching material science, was vigorously pointed out by Frederick W. Taylor in a letter to M. H. LeChatelier. "It seems to me of vastly more importance to teach the student, first, the broad general principles underlying a science; second, to show him the true scientific methods of investigation (such as were adopted by Moissan), and, third, to lead him to use his own brains and initiative in approaching any new subject, rather than to attempt to cram students with a mass of detailed information."

instruments of teaching, of little value in themselves. The success of such a course comes far more from the character, interest, experience, and intellectual power of the teacher and from his capacity to see behind the subject matter and the methods of his course, the purposes for which it is intended.

It is with full realization of the limitations of teaching methods, of the importance of varying and adapting them to local conditions, and of the predominant importance of the teacher, that the following suggestions as to courses on personnel problems of engineers and executives are given.

I. SUGGESTIONS FOR A DISCUSSION COURSE

The outstanding characteristic of a discussion course in personnel problems is that it may provide a condensed, systematic exposure of the student to the principal types of situation that an executive or engineer will encounter in dealing with human beings in his work. Unless the course is so conducted as to cause the student to think vigorously, systematically, and above all, independently about these situations, it is a slow and wasteful method of teaching. If this is done, however, this method is more than justified in the power of discernment and effective disciplined thinking it develops. Throughout, the course should be devised and conducted with this in mind.

A. Conducting Classes

1. *Developing Discussion.*

The essentials of developing discussion are the provision of worthwhile genuine problems, an orderly progressive development of the problems, and fair play in handling the students.

The problems must be genuine.—Students enter earnestly into the discussion of problems in which they are interested. To be really interested in the discussion of a problem they must believe that the problem is a worthwhile problem with which they are qualified to deal. If the problem is trivial or academic, students are unlikely to be interested in discussing

it. If there is an exact answer stated in the reading, the question is a "quiz" and not a discussible problem at all. If, after the class has made an honest effort to develop a sound decision by discussion, the instructor pulls a predetermined categorical answer out of the hat of his special information, the students feel defrauded and thereafter discussion is likely to be half-hearted. Usually the test of whether the discussion has been genuine and of value to the students is whether the instructor has himself in some degree modified or clarified his own opinion as a result of it.

The discussion must get somewhere.—Even vigorous discussion is of little value if it does not stick to the point and get somewhere. Unless it is confined to an orderly development of the problem, it tends to become discursive and ineffective. This makes progress slow, and bores all but a few loquacious students. Far worse, it confuses the discussion and develops habits of ineffective and disorderly thought.

It is not necessary or desirable that the discussion follow, topic by topic, some outline worked out by the instructor. Such a method can easily be carried to the point where the "discussions" would be little more than recitations under a new name. The students must be left free to explore the subject in their own way. Nor is it possible to tell in advance just what that way will be, or what combination of circumstances will give some formerly minor point unexpected importance. Nevertheless, if the instructor has the essentials of the problem well in mind, it is possible by asking questions at critical times, by picking out what is essential in some student's statement, by suggesting that diverting digressions be discussed after class, and especially by insisting that one point be cleared up before another is gone into, not only to keep the discussion within bounds but to make it an orderly progressive development of the problem.

Such orderliness of development is helped, especially at the start, by establishing a somewhat standardized sequence of approach. For example, the discussion of each problem may well begin with an analysis of the problem into its major

elements, and a careful elimination of any ambiguities. With classes using a psychological arrangement of material, the further development of the discussion may well follow in succession the principal steps in this arrangement. If such a standardized method of approach is observed with unimaginative rigidity, it will be a cramping and sterile influence. If it is flexibly and imaginatively employed, it may bring freedom as well as orderliness and thoroughness to the discussion. With the main course of the discussion thus charted, greater latitude in the exploration of the subject is possible without confusion. With the main course thus determined, regardless of what topics are brought up or what emphasis is given to particular points by special circumstances, the development of an orderly method of approach is assured.

Frank statements must not be taken advantage of.—In developing orderly discussion, care must always be taken not to discourage honest and frank statement of opinion. Unless a student is unquestionably talking merely to hear himself talk, he should be made to feel that his sincerity and the merit of what he has in mind are recognized, even though the point he brought up cannot for lack of time be gone into.

In answering discussion from the floor, it is always important to take a student at what he meant or would like to have said, rather than at what he actually said. Students, because of inexperience, frequently say things in a way that if taken literally is quite different from what they intended. While it is often desirable to insist on precise statement, this must be done directly. If the instructor differs with what was literally said when it was not what was meant, and publicly proves that what was said was wrong, the student feels that he has been unfairly treated. Thereafter he hesitates to attempt to express his point of view for fear of being taken advantage of again. I have seen this happen with a college teacher of considerable excellence. By that mistake alone, he ruined an interesting course.

If, on the other hand, the teacher catches and helps the stu-

dent to state the idea that he was earnestly feeling his way toward but was not able clearly to express or even entirely clearly to envision, the student gains a sense of renewed self-confidence in trying to express his ideas again. When the underlying idea has been recognized in this way the instructor can bring it up for further discussion by other students, or vigorously differ with it himself without in any way imperiling future responsiveness.

The instructor must be prepared.—It is no easy task to handle the free discussion of a lively group of students. The better the class and the more effective the course, the more lively and penetrating will be the excursions into aspects of the situation that for one reason or another have "struck home" to the students. Under the fire of statements, comments and questions, the instructor cannot follow the order of his notes. Often he hasn't even an opportunity to refer to them. Again and again, unexpected turns will bring up points his notes do not cover. Unless he has chosen problems that he understands "from the ground up" and has gotten them thoroughly in mind, he is likely to find himself in difficulties and the value of the discussion impaired.

Discussion groups.—In addition to class discussion, the formation of informal discussion groups of from three to six members in the latter part of the course may prove of value. In these groups the students go further into troublesome points brought up in class, and also discuss other problems, often their own. The fact that no instructor is present, while it makes discursiveness almost inevitable, brings about a freedom of discussion and a formation of independent judgment not possible in class.

As an inducement to the formation of such groups, students may be excused from certain reading if they attend a discussion group that meets regularly for a minimum number of hours, and one of their number undertakes to report attendance and the topics covered by the discussions. Usually there is little difficulty in getting students to join discussion groups.

Apart from the direct benefit to the student, such discussion groups often support classroom discussion. Questions debated in the groups are brought up at class, and points of view arrived at in the groups vigorously maintained. Also, the group discussions make clear to the student what in the class discussions he has failed fully to grasp.

2. *Giving Vitality to Class Situations and Problems.*

The importance of making the problem real.—The value of discussing a situation or a problem in class depends largely upon whether it is made real to the student. In the first place, this depends upon whether it is real to the instructor. If, and only if, he enters into it with the energy and enthusiasm of an actual problem that must be dealt with, will it be real to his class. If, and only if, it is real to him can he bring out during the discussion subtle influences and aspects that could hardly be reduced to written statement. For, to a large extent, the written statement of a problem is only an outline which he must fill in from his own background.

In the second place, how real a problem is to the students depends upon how well it is related to what the students have experienced themselves. Many students have actually worked on jobs during their summer vacations. This gives a helpful ground on which to build. Even when they have not worked, their own lives—their homes, their fraternities and their curriculum and extra curriculum work, have furnished valid experience with the major problems of human relations. If this actual experience of the students is built upon by relating the elements of industrial problems to it, a structure of feeling and understanding can gradually be erected that in the end will give a basis for sensing the realities of even such complex situations as group industrial relations.

Bringing discussion down to terms of direct speech and action.—Many problems can be made more real by causing the student to deal by action with certain elements. For example, in handling the problem of getting started in the practice of his profession, each student may be asked to write

a letter of application for the job he would most like to secure after graduation. This brings the problem right home to him. Almost at the start of the course, he not only finds that the course relates to his own life and career, but he is forced to get down from maxims, book statements and discussion to the doing of a job. Then if the next day the instructor sits at his desk and treats the letters as his morning's mail—opens them, reads them out loud and thinks out loud about them—the student is exposed to the experience of hearing his letter through the receiver's ears. "Nothing in this that arouses interest." "When a man has such a good opinion of himself, it must be hard not to have facts to back it up." "Here's a man who has done something and yet he doesn't blow about it!" When this is effectively done it has vigorous reality, sometimes so much so that months later the instructor finds himself burdened with requests to read over proposed letters to prospective employers.

Throughout the course there will be similar opportunities in the discussion of problems, where instead of asking what should be done, the instructor can assume the part of "the other fellow" whether he be superior, subordinate, colleague, salesman or buyer, and require the student to demonstrate his solution in direct discourse. Thus, the problem of what a young engineer, who is learning to operate a machine as his first job in the factory, should do if the workman to whom he has been assigned as assistant shows him how to falsify his production record, has an entirely different "bite" if the instructor translates it into direct discourse and says to the student who has given a descriptive answer: "Well, let's get right down into actual conditions. Assume that I am the workman whose assistant you have been made, and after tipping you off as to how to falsify your production-counter, I say 'See here, Jack—now you're wise, remember you and I are in the same boat and your production figures have got to be right—get me!' Now just what would you do or say at that point?"

Such a dive into direct discourse forces the student out of

the relatively easy area of theory into the harder area of action. It is in this improvisation of impact with intractable reality, however it is brought about, that much of the value of a course of this sort lies. It prevents it from being the mere absorption of information as to practices and theories, and causes it to bring about in the student a capacity to deal effectively with actual conditions.

Bringing the student into contact with experience.—Certain problems, instead of being discussed at all, can be directly dealt with throughout. For example, in studying the problem of handling subordinates, it is not difficult to find cases which can be actually brought into the classroom. The problem of discharging a worker who, in spite of good attendance, good attitude and consistent effort, has failed to measure up to production standards, is of this sort. For the purpose of handling the problem, different students may be assigned to executive positions such as foreman, superintendent and employment manager. If the circumstances surrounding the particular situation require it, a student may also be designated employee representative. It gives greater reality to hire some person from outside of the class to take the part of the employee. Usually some person who has had sufficient industrial experience to enact the part vigorously, and who is willing to do so, can be found. It is essential that the class keep absolutely silent during such a problem, but if it is seriously gone into and the importance of silence made clear, the students soon get so interested that there is little difficulty in this regard.

The facts should be written out and agreed to in advance. The student-executives, subject to the approval of the instructor, should prepare what they consider proper personnel records. With some problems, the actual incident which gave rise to the need for disciplinary action may be enacted in the classroom. From the time the principal facts are set down or enacted, the entire proceeding is spontaneous without pre-arrangement or "coaching from the side lines." Each person handles his own job as occasion requires, and the

entire situation is carried out in the classroom—the foreman's conferences with the employment manager, the notification of the employee who is seated in the midst of the classroom which is assumed to be the work room, the first conference with the foreman, the later conference with the employment manager. Whatever course the case takes it is followed through by actual handling.

It adds to the interest if competing teams are organized, each team handling a different problem in a restricted time and the class voting on the basis of predetermined standards, as to which team did best. Further interest and reality is produced if one or two executives in the community are asked to sit in to observe and to criticize the handling of the situation by the students.

Problems of the buying and selling relationship such as arise in getting a design or program adopted, securing an assistant, determining whether the request of a subordinate is sound, hiring a man or securing a job, are also well adapted to classroom handling. Any one of these situations typifies the factors involved in the others. The problem of hiring a man or of securing a job furnishes an exceptionally vivid illustration of the principles of the buyer-seller relationship, and can be reproduced in class with exceptional reality. The students selected to do the interviewing may be furnished with requisitions ranging from common labor to engineers. Young men and women who have had varied amounts of education and industrial experience, can be hired to come before the class to be interviewed. If they are paid twice as much if they succeed in "getting hired" as if they fail, they will fairly accurately reproduce the behavior of a person "out of a job." If they do not know what job requisitions the students have been given to fill, and if neither the instructor nor the students know anything about the people being interviewed, most of the essential conditions of actual interviewing will be present.

Such interviewing is usually too difficult for an individual student to carry through alone. By making teams of three,

each member of which in turn is to carry on the interview from where his predecessor left off, when one man comes to "the end of his rope," the next, who has had the advantage of watching the interview thus far, is usually able to go forward effectively. After the students have done their best it is helpful for the instructor to complete the interview, bringing out points which the students have missed.

After any problem has been handled in the classroom, the values of this experience may be driven home by discussing at the next class what was and what was not well done. Such cases call for especially full understanding on the part of the instructor. If he has never handled a similar situation in actual life, it is important to enlist the assistance of practical executives in conducting such a problem. Without this assistance, the fact that the instructor has merely a book knowledge of human contacts may become painfully apparent when he is thus brought into contact with reality.

Problems of various sorts may similarly be dramatized so as to be dealt with instead of discussed. Of course, where the students can be brought directly into a work shop and assigned duties, there are exceptional opportunities for supervised actual experience. Still, even when this is possible, there are certain types of experience that can be provided more effectively by class dramatization than work shop conditions would permit. Such direct experience is preferably introduced fairly well on in the course when the students are sufficiently advanced to understand the complex interplay of the subtle factors involved in actual human contacts. Such dramatization can only be applied to certain types of cases, and is too time-consuming to be frequently resorted to. Still, a few such contacts with reality can permeate an entire course with their influence, not merely greatly increasing interest, but by demonstrating the distinction between management theory and the actual management of men, remove from the discussion of problems the glibness with which inexperienced students tend to "round off" difficult situations with easy generalities.

B. Exercises and Examinations

In teaching a course that differs from the standard engineering courses in subject matter and method, exercises and examinations are exceptionally important. They prescribe what the students must accomplish in order to receive credit for the course, and indicate to them what the faculty think is most important for them to get out of it. Consequently, the type of exercises and tests given largely determine the type of studying which the student does.

Exercises

Throughout the course the preparation of problems for class discussion should be emphasized as the primary work of the course. Occasionally, especially at the start, it is desirable to require the students to write out and hand in for criticism their analysis of a problem assigned for class discussion. This not merely insures that the students have made adequate preparation, but gives the instructor an exceptional opportunity to guide the students in developing an effective method of approach to the problems.

Later in the course when the students have a fairly well-rounded understanding of the field, it is of value to have them work out a careful analysis of some problem taken from their own experience. If the student has never worked in an industrial concern, his personal contacts at home or college are almost sure to provide suitable personnel situations. If a thoroughgoing psychological understanding and method of approach have been developed, they will give such a study of an actual problem in the student's life especial value. Such an analysis is so instrumental in making the course an effective part of the student's equipment for life, that it may well be made a major feature of the course.* Repeatedly,

* *Note:* This may be done, for example, by giving as much credit for it as for the mid-term examination. By limiting the paper to a few pages and yet giving so much credit to it, its importance is emphasized and the student induced to prepare it with exceptional care. Mature consideration may be promoted by requiring a statement of the facts of the problem to be prepared several weeks before the final analysis is due.

after such a careful study of a problem of their own, students have taken a new interest in the course through discovering in it a means of better understanding themselves and of better handling their present as well as their future problems.

Tests and Examinations

If it is found necessary to provide frequent tests to insure that the students do the assigned reading regularly and understand it, it is preferable for these tests to ask questions that call for thought, not mere retention. While of necessity they must be short, it is important that they do not throw undue emphasis upon the mere temporary retention of information.

Since students usually discover in advance the type of examinations given in any course, examinations as well as tests and exercises determine what the student will emphasize throughout the year. Because of their length and their position at the end of the main divisions of the course, they give a better opportunity to examine the ability which the student has developed than other means. If the ability to repeat information, rather than the ability to deal with actual situations, is asked for in the examinations, this is likely to relate back and cast its shadow over the entire course, diverting the students' attention from the acquisition of understanding and ability through class discussion, to the mere amassing of information. Since from preparatory school days, in courses such as history and government where there are no precise manipulations to master, the average student has been habituated to amassing and repeating information, it is no small task to cause him to abandon his attitude of seeking to get and to be able to repeat "the dope." Consequently, it is of first importance that the examinations contain few factual questions and consist primarily of original problems of such a nature that no solution in exact categorical terms is possible.

Only such problems can measure the student's ability to recognize and deal effectively with the human aspects of in-

dustrial situations which it is the main purpose of the course to develop. Only such problems can insure the direction of his efforts to the acquisition of this ability.

C. Problems and Situations

Selection and Arrangement of Problems for Discussion

The course should comprehend problems that typify the main types of situations with which an engineer or executive has to deal. Each problem should be chosen because it illustrates the operation of some fundamental principle, or illustrates some important type of human contact or industrial relations situation. What the exact "scenery" of the particular problem may be is relatively unimportant: what is important is whether in understanding it and reaching a sound conclusion in regard to it, the student has progressed in his understanding of human nature and of the factors involved in human relations in industry. To insure this the problems discussed in class must be arranged in an orderly sequence which will make the study of each succeeding problem bring about a systematic development of the student's understanding of the field.

Since a single fundamental principle or type of experience may be illustrated by a variety of situations, a wide choice of subject matter is possible without impairing the particular order of development of the subject that has been determined upon. Hence it is possible to arrange the types of situations in about the order in which the student will encounter them as he progresses in his profession, and at the same time cause the principles illustrated to follow some more fundamental plan. For example, an arrangement of problems starting with the problem of getting a job (and the converse problems of selecting and hiring men), taking next the problems of fitting into a new environment and learning from experience (with the converse problems of training and developing assistants and employees); and after various intermediary steps culminating in problems of employee representation and of unions, follows roughly the course of the

student's future progress and yet proceeds systematically from a study of what is unchangeable and changeable in men, through habit formation and understanding, and other major fields of individual psychology, to problems of group psychology and the integration of group conflict.*

Since a science of human nature is being developed by psychologists and psychiatrists, and since it is already both being effectively applied by experts to particular industrial situations, and being utilized by executives as principles for the guidance of their work, it is desirable that engineering students be equipped to understand and work with it. Already a sound grounding in the fundamental psychological principles which underlie human relations has become of great value to the executive. Through a grasp of these principles he gains a more profound understanding of human nature and a surer touch in dealing with it than is possible by rule of thumb methods alone. Valuable as such scientific understanding is to executives today, it will be much more valuable when the students now in engineering schools reach mature executive positions, for psychology and psychiatry are making rapid progress. It is fundamental, however, that psychological principles be learned in actual application to problems, and the psychological understanding so gained utilized in handling problems throughout the course. To attempt to give a "psychological background" in a few lectures is likely to make psychology for the student a thing both superficial and apart from actual life. To teach psychology in application to problems is to make it a growing basis of understanding which the student knows how to put to practical use. On this account there are important advantages in arranging the problems in a systematic psychological sequence.

If students have not had previous courses in personnel problems, especially if they have not previously taken courses conducted by the discussion of problems, it may be helpful

* *Note:* Suggested arrangements for a course in Personnel Problems for Engineers and Executives on both a psychological and an industrial basis is given on pages 24 to 31.

to preface the course with some broad introductory problem which will both accustom them to the discussion method of study, and will bring them to realize the extent to which personnel problems are involved in what they have looked upon as exclusively engineering situations.

The Qualities of a Good Problem

To deal with a problem superficially is misleading. Even worse, it develops habits of superficial judgment. On this account, it is important to select problems with which the students are thoroughly qualified to deal.

At the start of the course or of a major sub-division, problems must be sufficiently simple to display clearly the fundamental factors at work. At this time it may even be desirable, in order to prevent the operation of fundamental principles from being confused by the discussion of the local incidents of a particular situation, to abandon the discussion of particular situations and to state the problem baldly in general terms. ''Under what conditions is exceptionally low turnover desirable and undesirable: among employees? among executives?''

As the student progresses, his capacity to comprehend and to deal with more complicated and difficult material increases. It is thus essential that as the course progresses the fundamental factors of the problems be increasingly overlaid with ''scenery'' so as to exercise the student's powers of recognition and discrimination. It is equally essential that the later problems involve the recurrence in subtle variation and complex interrelation of the principles developed in the earlier problems. Still, throughout it is important to make sure that the problem is not too complex for effective handling by the student with the knowledge and ability at his command.*

* *Note:* In law schools where the case method was developed, the cases studied are legal ''precedents.'' Besides, the issues in law cases are carefully defined in advance, and the decisions confined to the specified issues. If the discussion method which has worked so well in law schools is to be successfully employed in teaching students to manage men, it

It is not possible, however, to be dogmatic about problem material. What works well with one instructor or group of students may not with another. The above recommendations are of value primarily in suggesting the stresses to which problem material will be subjected when put to use. Each instructor must work out for himself, largely by experimentation, what sort of material is most valuable for him and for his particular classes.

II. SUGGESTIONS FOR A LECTURE-RECITATION COURSE

A lecture-recitation course, like the suggested problem course, should seek to cover the typical personnel situations which an executive or engineer will encounter in his work. In treatment, the course should emphasize the position of the engineer or operating executive. Since little has been written directly from this standpoint, an important function of the lectures will be to interpret from this angle the material provided by the reading.

In general, a lecture course would follow by the lecture method the same sequence of subjects and the same reading in regard to them as a discussion course. The arrangements of subjects and reading given on pages 31 to 35 are as applicable to a lecture course as one taught by the problem method. There is the same desirability of a sound psychological approach when this can be provided. The suggestions made for conducting a course by the discussion of problems should also be looked upon as suggestions of measures which, by adaptation wherever practical to the conditions of the particular lecture course, can make it more effective in de-

must be adapted to the different conditions. Since there is nothing in industrial situations comparable to the legal definition of issues, industrial situations must usually be simplified and unified before being presented as class problems, so as to confine them to definite factors. Since industrial situations are not precedents, it is usually better to discuss industrial problems on a broader basis than that of the outcome of one particular case.

veloping the capacity of the students to think incisively and practically.

In a lecture-recitation course, as well as in a problem course, there are important opportunities for bringing the material out of the realm of theory and repeatable information, into actual practice. Recitations, exercises and tests need not be confined to mere repetition of the material provided in the lectures and the reading, but can call for original application of this material to engineering and executive problems. Although the problem method is not adopted as a whole, there will probably be times when the discussion or even the acting out of some especially suitable problem can be advantageously introduced. Even the occasional introduction of problems adds a sense of reality to the entire course and keeps the student thinking of the material in practical terms. For, how much value the student derives from a lecture course, as from any other, in preparing himself to embrace the opportunities and to handle the problems that will arise as he progresses in his profession, depends primarily upon how vigorously and thoroughly the course caused him to think.

III. Suggested Psychological Arrangement of a Course in Personnel Problems of Engineers and Executives

The topics listed can be made the subjects of either problems or lectures, depending upon the method of instruction used in the course.

Introduction

The influence of engineering developments upon industrial relations, and the importance of personnel ability in engineering or executive work.

Part I

The Principles of Psychology as they apply to Engineering and Executive Problems

The first part of the course aims primarily to give a sound understanding of the major psychological principles in their

application to industrial situations so that the student will be equipped to use them later in solving well-rounded industrial problems. The cases used should therefore be sufficiently simplified as to bring out clearly the particular psychological principles they are designed to illustrate.

I. *Sources of Ability and Character*

The significance of human traits and the degree to which they can be changed, as illustrated by problems of selecting and securing a job and conversely hiring and testing employees.

II. *Habit*

The acquisition, characteristics, and influence of physical and mental habits as illustrated by problems of methods study, job analysis, and special problems of trade training.

III. *Memory, Attention and Understanding*

The process of memory as illustrated by problems of the acquisition of trade knowledge.

The nature and importance of associations as illustrated by problems of the effect of the working environment upon the working force.

What attracts attention, as illustrated by problems of safety.

Variation in scope of attention and its consequences as illustrated by problems of monotony and strain.

The principles of understanding and the influence of habit on understanding as illustrated by problems of employee and executive stagnation and its prevention by education and educational experience.

The interrelation of habit, memory, attention, and understanding as illustrated by a thorough problem of employee or executive training.

IV. *The Forces of the Personality*

Desires and their stimulation, standards and the process of censoring, and the overcoming of self-control by such means as drawing near temptation, fatigue, fear, rationalization,

fixation of attention, and development of escape patterns in revery; as illustrated by problems of employee and executive misconduct and self-control.

V. *Group Behavior*

The influence and behavior of acquiescent and of resistant groups as illustrated by problems of the behavior and management of employee groups.

VI. *Conflict*

The psychology of conflicts between individuals and between groups as illustrated by simplified problems of discipline, inter-departmental friction, or reorganization.

Part II

Dealing with Problems of Executives and Engineers by the Application of Both Practical and Psychological Principles.

In this part of the course problems should be studied as a whole, not as illustrations of some special principle. Accordingly, more well-rounded problems should be selected, and they should be studied thoroughly from all angles, emphasis being placed on the practical handling of the situation. During this part of the course, the handling of problems in class by action instead of merely discussion, is especially important.

I. *Problems of the Engineer as an Employee*

Problems of personal conduct in fitting into his job and dealing with associates and superiors such as those in regard to what a young engineer should do when asked to join a union, when a fellowworker seeks to induce him to curtail output or falsify records, when a superior takes credit for his suggestions, or when he has failed to gain expected promotion.

II. *Problems of Handling Men as an Executive*

Actual interviewing, testing, selling or handling breaches of discipline in class, and such problems as the taking over of

a new plant or department, as illustrations of the principles underlying the executive-employee relationships.

III. *Problems of Wages and Incentives*

Problems arising out of the determination of wage levels, and the application of various forms of financial and non-financial incentives.

IV. *Problems of Internal Organization*

Problems arising out of proper and improper organization of factory functions, as illustrating the interrelation of problems of organization and problems of behavior.

V. *Problems of Industrial Relations*

Problems arising out of irregularity of employment, and out of the absence and the existence of employee representation and of unions, etc.

IV. Suggested Industrial Arrangement of a Course in Personnel Problems of Engineering and Executives

The topics listed can be made the subjects of either problems or lectures, depending upon the method of instruction used in the course.

I. *Introduction*

The influence of engineering developments upon industrial relations, and the importance of personnel ability in carrying on of engineering or executive work.

II. *Problems of the Recent Engineering School Graduate*

(*a*) Selecting and securing a job and conversely hiring and placing employees. (This material may be made illustrative of the broader problem of buyer-seller contacts.)

(*b*) Making a place for oneself and developing in one's work, and its parallel, fitting employees to their jobs and seeing that they progress.

III. *Handling Men as an Executive*

(*a*) The executive task.

(*b*) Problems of working methods and conditions.

(*c*) Problems of wages and incentives to effort.

(*d*) Problems of discipline and leadership.

IV. *Industrial Organization*

Problems of the interrelation of factory functions.

V. *Industrial Relations*

Problems arising out of irregularity of employment, and out of the existence and of the absence of employee representation and of unions.

IV. SUGGESTIONS FOR READING MATERIAL FOR A COURSE IN PERSONNEL PROBLEMS OF ENGINEERS AND EXECUTIVES

This list has been confined to a few outstanding books on each topic. Which books, from this list or the wide range of books published in this field, will be of most value will depend largely upon the character of the individual course.

A well-rounded background for understanding industrial relations and management of men is by no means confined to books directly relating to business and industrial personnel problems. A man's capacity to deal with men is largely measured by his understanding of men and of life. Any reading that broadens his knowledge of human behavior or that causes him to think about life penetratingly, whether it be biography, history, sociology, science, psychology or literature, is valuable background for executive work. With engineering students especially, because of their specialization during undergraduate days, the encouragement of a wide range of worth while reading is important.

I. Management of Men

A. The Job of the Executive

Executive Conduct in Dealing with Men

Craig & Charters: Personnel Leadership in Industry. McGraw-Hill.

E. H. Schell: Technique of Executive Control. McGraw-Hill.

G. H. Lorimer: Letters from a Self-Made Merchant to his Son. Sears.

Foremanship

G. L. Gardner: Practical Foremanship. McGraw-Hill.

C. R. Allen: The Foreman and His Job. Lippincott.

The Responsibilities of the Manager

S. A. Lewisohn: The New Leadership in Industry. Dutton.

S. Webb: Worke Manager Today. (English.) Longmans Green.

B. Personnel Management

Scott & Clothier: Personnel Management. Shaw.

Tead & Metcalf: Personnel Administration. McGraw-Hill.

G. S. Watkins: Labor Management. Shaw.

C. General Treatments of Management

E. D. Jones: The Administration of Industrial Enterprises. Longmans Green.

D. S. Kimball: Principles of Industrial Organization. McGraw-Hill.

II. Psychology of Human Relations in Industry

A. Psychology of Management and Industrial Relations

E. D. Smith: Psychology for Executives. Harper.

B. *Psychiatry in Industry*

V. V. Anderson: Psychiatry in Industry. Harper.

C. *Testing and Industrial Psycho-Techniques*

H. E. Burt: Employment Psychology. Houghton Mifflin
J. O'Connor: Born That Way. Williams & Wilkins.
Kornhauser & Kingsbury: Psychological Tests in Business. U. of Chicago.
H. C. Link: Employment Psychology. MacMillan.

D. *Psychological Background*

F. Allport: Social Psychology. Houghton Mifflin.
J. Dewey: Human Nature and Conduct. Holt.
M. P. Follett: Creative Experience. Longmans Green.
B. Hart: Psychology of Insanity. Putnam.
J. Hunter and others: Psychologies of 1925. Clark U.
W. Koehler: Gestalt Psychology. Liveright.
E. D. Martin: The Behavior of Crowds. Harper.
H. A. Overstreet: Influencing Human Behavior. Norton.
A. Ruckmick: The Mental Life. Longmans Green.
A. S. Tansley: The New Psychology. Dodd Mead.
R. S. Woodworth: Psychology. Holt.

III. Industrial Relations

A. *General*

J. A. Fitch: Causes of Industrial Unrest. Harper.
R. S. & H. M. Lynd: Middletown. Harcourt.
C. H. Parker: The Casual Laborer. Harcourt.
W. Williams: What's on the Worker's Mind. Scribners.
W. Williams: Mainsprings of Men. Scribners.

B. *Employee Representation and Unions*

E. R. Burton: Employee Representation. Williams & Wilkins.
P. F. Gemmill: Present-Day Labor Relations. Wiley.
J. M. Hobson: Conditions of Industrial Peace. MacMillan.

R. F. Hoxie: Trade Unionism in the U. S. Appleton.
B. Selekman: Employee Representation in the Coal Mines. R. Sage.
B. Selekman: Employee Representation in a Steel Mill. R. Sage.

C. Profit Sharing

A. W. Burrett and others: Profit Sharing & Stock Ownership. Harper.

D. Mechanization and the Worker

S. Chase: Men and Machines. MacMillan.
H. Dubreuil: Rabots or Men. Harper.

E. Unemployment

W. H. Beveridge: Unemployment. Longmans Green.
H. Feldman: Regularization of Unemployment. Harpers.
S. A. Lewisohn and others: Can Business Prevent Unemployment? Knopf.

IV. PROBLEMS AND CASES

Harvard Business Reports No. 4. Shaw.
These have some excellent cases as reference material. Most of them are too complicated to be suited for discussion as "problems."
Schell & Thurlby: Problems in Industrial Management. Shaw.
Section V, pp. 235 to 342 gives 33 personnel problems, with test book references.
E. H. Schell: Technique of Executive Control. McGraw-Hill.
This book has some excellent problems of the simpler type at the end of sections.
E. D. Smith: Personnel Problems.
Copies of an unpublished folder of "Personnel Problems" can be procured from the Department of Industrial Engineering, Yale University.

V. Special Reports

The following organizations issue important reports of investigations, or statements by leading authorities, upon the most pressing current personnel and industrial relations problems.

American Management Association: Bulletins.
National Industrial Conference Board: Reports.
The Taylor Society; Bulletin of.

The headquarters of these organizations are in New York City.

Discussion

Sam A. Lewisohn: Well, gentlemen, there is very little for me to add after Professor Smith's brilliant discussion; in fact, discussing his paper makes me feel a little like a bit of insulating material trying to talk after a live wire. It was worth the price of admission and the trip up from New York to hear Professor Smith's analysis of his teaching methods.

His discussion this evening is the culmination of the efforts, as you know, that have been made for a number of years by such members of this Society as General Rees and Dean Sackett and Dean Kimball, Dean Potter, Mr. Hammond, and many others, to have this subject of human relations and labor relations adequately treated at the engineering schools. I am not an educator; I can't talk as Professor Smith talks. I see the necessity of having the students of engineering schools acquire some background in this subject from the point of view of an executive who has seen many men fail to make the maximum use of their opportunity, many engineers fail to make proper use of their industrial opportunities because of a failure to acquire this background that Professor Smith has sketched.

I wonder if you educators quite realize the tremendous responsibilities that you shoulder? General Rees spoke of it this afternoon. As I was thinking and listening to his talk, and that of Professor Smith this evening, I was impressed by the tremendous opportunities that educators have. After

all we executives can only take what you send us. Educators really make the future. I feel I have the answer to the old question of what comes first, the chicken or the egg. My answer would be the educator, because after all he starts the trend of human events. If educators fail to turn out the proper human material opportunities are lost that can never be reclaimed.

As many of you know, I have been one of those who have been most emphatic about the necessity of having some formal course given to your students in human relations and labor relations. At the same time, I agree with Professor Smith that it must be taught with great discrimination by teachers who realize the danger of giving students the idea that the mere following of a certain routine will solve their problems. It is essential in teaching this subject, this very subtle subject in which we are just beginning to feel our way, that intuition be retained. We have lost our natural senses in many directions. For example, we have lost our sense of smell. We don't want to lose our intuitive sense in the direction of our psychological understanding of our fellow men. So in these matters of human relations, it is most important that you don't turn out men who approach the subject too self-consciously, whose whole attitude in these matters will be tinged with affectation. A synthetic personnel manner is not apt to be effective.

As Dean Sackett said to me this evening when I was talking to him, it isn't a subject that can be taught by book. It must be taught by getting the young man to think through the problems of his human contacts. He must at least be made to realize when he gets out in life that he is confronted with a problem in formulating his attitude toward his fellow human beings, particularly when it comes to the handling of labor relations.

I have spoken of the danger of a man becoming too self-conscious in these matters. Well, we have an analogy in the field of salesmanship. I don't know if any of you have been exposed to the blandishments of salesmen who have acquired a sort of a "canned" salesman manner, but in some

cases one feels that salesmen have acquired their art through a correspondence school. It reminds me of a case that I heard about of a young man who had taken a correspondence school course in salesmanship, twenty lessons for twenty dollars, and he had been taught certain stereotyped movements to go through in approaching his prospect. So when he came to his first prospect he put his two fingers, as he was taught, upon the table and he said, "My dear sir, I know how busy you are but I do hope you have a minute for me."

At that the hard-boiled buyer said, "Oh, say, I took that course myself. Don't go any further."

I merely mention that case because there is a danger that if the teaching of this subject is caricatured, if it is taught in a formal manner, more harm will be done than good, and the students will be turned out with a self-conscious attitude toward the whole subject that will make them as awkward as the salesman I spoke of.

As Professor Smith has said, the way you can avoid making the students self-conscious in these matters is by refusing to give them any standardized receipts, any standardized method or answers to these problems, and instead adopting the device of exposing them to the typical situations with which they will be faced in their future life and making them think through such situations.

This is particularly important when it comes to the problem of labor relations. Professor Smith has naturally spoken about the broader subject of human relations. In a way, you can't divide the methods that a young executive must use in his relations with his superiors and with his associates and those that he must use with his subordinates. Yet I have been particularly interested, as you all know, in the problem of the attitude of engineering executives to their subordinates, particularly to the rank and file of workmen, because here we have a problem that is a very, very important social problem, and one that is tinged with dynamite if it is not properly solved.

It is important that students who are taught to think about the subject realize that there is no boiler-made method

of approaching personnel problems; that they will have various different groups to handle; that in some cases slightly different methods must be used from other cases. A different manner must naturally be used in dealing with Mexicans down in Arizona where some four plants are situated, or with the mountaineers of Tennessee, who still speak a sort of Elizabethan English, or with the Slavs, or the Italians. Each group requires a different personnel manner, a different formula. In fact, there is no formula, and we must avoid giving students the impression that boiler-made methods will apply when it comes to personnel problems.

We Americans—and when I say Americans I speak of North Americans—have a head start when it comes to the problem of human relations, for in this Continent of ours we have nothing of the caste system that they have in Europe. This may sound somewhat afield, and yet any observer who goes to Europe is impressed with the fact that the caste system impedes their industrial progress, for there is not that easy camaraderie between employers and employees that we take for granted in this country. It is hard for us to visualize the conditions that still exist, particularly in England, France, and Germany, with regard to the relations between executives and their men.

I was particularly impressed in reading a book on this subject by a French workman named Dubreuil, a very brilliant observer who worked in this country for a year or two in four of our factories. I had the opportunity of meeting Mr. Dubreuil this year in France, and both from his book and from what he told me, I was impressed with the impression he gained of the greater democratic manner that prevailed in this country as compared with that which prevails in the factories of France. He said that he was perfectly astounded at the camaraderie that existed here between the employers and the employees. He particularly comments upon the absence in this country of any of that attitude of patronization that is common in Europe, and particularly in France, where the employer is apt to go up to his employee and say, "Mon brave," in a patronizing way. That may seem a very subtle

thing, but I am convinced that it is something that has been an important factor in our industrial success, the fact that we have not got this caste cleavage to overcome with the consequent resistance on the part of the men.

I regard this whole element of good nature, this natural, easy-going sportsmanship with which we are blessed in this Continent, as something to build upon. It is a subtle thing that should be emphasized, and I mention it as indicating one of the imponderables that you have to teach to your students. An engineer is a natural democrat, and yet within his absorption in problems having to do with inanimate matters he is apt to become aloof and fail to intrude this very subtle element of good nature that makes such a large difference in our industrial relations. I was thinking the other day that it is rather remarkable that there is one element that one never sees discussed in connection with the personnel problem that is a very important factor, and that is the element of a sense of humor. Humor is a very important component of the fine social spirit that pervades both our social and industrial life and it is an essential part of the sanity of the North American outlook. It is something that can be well accentuated.

Only a few months ago I saw a splendid piece of personnel work performed at one of our plants that took into consideration this element. It has been the custom at our plant to give a gold medal to each man, whether he is a workman or a member of the staff who has performed twenty years of service. In presenting the medals the personnel manager had prepared humorous stories about each man to whom the medal was presented, somewhat similar to the approach at a class day ceremony at a college commencement. Some amusing incidents in the man's career, real or fanciful, some takeoff was related, and it was remarkable what a success the meeting was and how fine a spirit it engendered.

This matter of intruding the comic spirit, in a plant, may seem a very unimportant thing as compared to some of the larger problems, and yet it is a very important matter when it comes to maintaining the morale of an organization.

I don't want what I have said to lend the least support to those who maintain that personnel relations are such an intangible, subtle matter that they can't be taught, and particularly that they can't be taught in engineering schools. Nor do I wish to intimate that because we in North America have the advantage of this democratic tradition it is not necessary to go any further. Of course, I believe this subject can and should be taught. We should build upon our tradition, not use its existence as an excuse for neglecting the subject.

As far as the matter of danger of self-consciousness is concerned, you might as well conclude because such games as tennis and golf are difficult to teach, and because there is a danger that when you are taught the game you become self-conscious, that the principles of the game cannot be taught at all, and that formal instruction is useless. Some people who have this notion, particularly in golf, refuse to take any training at all, and their game is execrable. The proper method is to take the formal training and then to allow it after one has consciously gone through it, to become absorbed by the unconscious, and finally the self-consciousness disappears. Similarly a formal training in this subject of personnel relations may possibly create a slightly self-conscious attitude for a short time, but the content of the instruction can finally be absorbed into the man's personality so that when he comes out into the executive field he will be better equipped to handle human relations.

I have spoken mostly about the attitude of executives towards their employees, but let me say that a certain knowledge of modern psychology, of human behavior is a most important advantage in one's relations to one's salaried associates. I was thinking, as Professor Smith was talking, of one executive that is absolutely invaluable to our organization, but a very temperamental individual, a man who did not usually stay with any organization more than two or three years at the most, and whom we now have with us about fifteen years. I can assure you that the reason he has been with us this long is because some of us know a little about

the psychology of human beings and are able to meet his psychological difficulties.

Professor Smith has spoken about several men who have come to his attention, engineers who have failed to reach positions of maximum importance because of their failure to have an understanding of how to handle human relations. Let me say that in my own experience in the last year in addition to cases to which I have called friends' attention, I know of several cases in which men have been turned aside, men with high technical equipment, because of their failure to understand how to handle human relations.

Mr. Owen D. Young, only a year ago at a meeting in New York of a small group, some of you will remember, spoke of the fact that very often his own company was unable to fill important positions of what he called high command in Europe from their own engineering ranks because of the failure to find men with a grasp of broader human problems.

Therefore, I am glad that we have had the opportunity of hearing from a man who has had such practical experience in the industrial field and in the teaching field as Professor Smith, to tell us how this subject of human relations can be taught without the danger of too great formalization, and in a practical way.

Let me, in closing, reiterate that you engineering educators have a very, very important responsibility which you should consider in molding what General Rees referred to as the industrial statesman of the future. I hope you will take advantage of the opportunity afforded to you to make history.

Joseph W. Roe: The talk you have heard tonight is significant. It represents something certain to have a wide influence in engineering education which started some years ago in a conference called by Mr. Lewisohn at his own home, where he put this challenge of training for personal leadership to engineering educators, and this is a definite step toward what he had pictured at that time.

It is evident to all teachers here that there is "something doing" in Elliott Smith's course and that the great asset in

that course is Elliott Smith himself. Without him, his vision, his personality, and his experience, the course would be dead —with these in it is alive.

No subject needs real life more than this and I cannot conceive of such a course as this being taught successfully by a routine teacher even from the reference given in this very course. Mr. Smith brings out clearly that if a student's later experience is relied on only, it is costly, brutal, and haphazard, and its lessons often come too late when the learner has been wrecked in the process of learning. He brings out that the mistakes rarely are clear, and causes are not tied up with the effects often until too late. He, therefore, uses by real cases brought from the wealth of his own experience and his wide contracts to put boys into the situations as nearly as he can reproduce them, without textbooks, to get their reaction and to train a right attitude.

In just this aspect the coöperative system is the greatest adjunct a student can have in connection with such a course as this because the boy meets these cases in his own experience. If he has received raw treatment from a foreman he knows the reactions. This has come out in my own classes. For instance, a coöperative boy one time brought up this case: He had been on an inspection job and had discovered certain faults running in the output. He diagnosed the fault and knew just where it occurred, on what machine, and what was the matter with it. He went to the workman and he pointed it out to him and told him what the trouble was and how to cure it. The foreman came along and bawled him out for doing it. He carried it up to the superintendent. Now here is a problem: which should the superintendent side with, the boy or the foreman? This case was a very real one to that boy.

Anything of that kind, either from experience or from experience through the teacher, which can give these problems to students systematically and get them human-minded, is good. We talk about getting motion-minded. What we want to get is not sentimentality, not the idea in business that it is an eleemosynary institution, but that there are real

human values in there and if I understand Elliott Smith's objective, it is to create an attitude of mind, and with that attitude of mind sound, then the real experience from the outside is going to be obtained at less cost, with greater effectiveness, and much sooner. If this can be brought about for industry, it will be a gain for the boys and it will be a gain for the school.

President Rees: There are just two points I would like to comment on in Professor Smith's very excellent paper. The first is with reference to an experience in industry. Before the war a few far-sighted companies were taking an interest in personnel work, and in human relations in industry. This personnel work expanded tremendously during the war, and we had so-called personnel efficiency experts who came into industry and had formulæ for the solution of all the problems in human relations. I want to pay tribute, however, to a number of intelligent men who attacked this problem with an open mind and contributed greatly to the difficult human problem that developed during the war. At the close of the war industry was not convinced of the value of this human relations problem in business, and as you all witnessed, during the depression of 1920 and 1921, many of the personnel activities in industry were abolished or discarded. The most enlighted industries, however, held to a wise personnel policy and kept a personnel staff for the study of human problems. Now the success of personnel work in industry since 1920–21 has been due to the realization that the personnel problem is an operating problem, that those who devote their whole time to personnel work are mostly staff men who serve the line. That means that every man in the operating organization of industry is a personnel man, from the President and General Manager on through the levels of the executives and the supervisory forces, down to the first line foreman.

I simply want to bring that out, that these problems are being met today solely because of the realization that the personnel problem and the problem in human relations is the business of everybody. For that reason I want to empha-

size the importance of engineering students coming to us in industry with an idea at least that there are human problems in industry which are the most important with which he has to deal.

The second point I would like to make is with reference to an impression that I received from Professor Elliott Smith and from Mr. Lewisohn, even from Dr. Roe, that this was too hard a problem for us to tackle. I want to bring that same conception of personnel being the problem of everybody, right down to every individual teacher on the faculties of the engineering colleges of the country. It seems to me that all of the members of the Society for the Promotion of Engineering Education sense the tremendous importance of human relations in industry, and the importance of helping our students to an appreciation that there are such problems. This appreciation should stimulate each individual teacher, whether he is teaching drawing or thermodynamics, or some of the many courses in electrical engineering, to pause every once in a while in the technical problems he is presenting and indicate that right in this and its application, in the actual experience of the student in the future, there is likely to be involved a human problem.

While we must have brilliant men who have devoted their life's attention to this matter of human relations, like Professor Smith has done, we don't want to make this too hard. We can all contribute, and then in addition, wherever it is possible, organize the kind of a course that is indicated in Professor Smith's most excellent paper. But let us all remember that this is an operating problem, that you have an operating problem on the campus, in your classes, in your laboratories, in your drawing rooms, in your evening classes, and in all your work, to emphasize that after all the most important problem in business today, as I said this afternoon, is that of human relations.

Professor Roe: Elliott Smith is a pioneer in this work. What do we want to gather from his experience? We should ask ourselves several questions. In the first place, is this type of training needed and worth while? In the second

place, shall we go into it? In the third place, what is the first step? It is not to get a textbook and put such a course in the catalog, but to select and train the right kind of man to do the work. That is the first and most important element. You probably have, as Professor Williston has said, men in your faculties who have this spirit. Any man who worked under, or was taught by L. P. Breckenridge, knows what is meant. If you have any man with that kind of spirit he is the one to take leadership in this kind of a field. I think it can be done. The essence of what we have in mind is to develop in engineering students by the time they graduate, whether in our own work only, or with the help of cooperative work, a certain attitude of mind not only toward workmen but toward their equals, and toward their superiors, which permits growth and development through experience later.

INDUSTRIAL RESEARCH METHODS AND WORKERS*

EDWARD R. WEIDLEIN

Director, Mellon Institute of Industrial Research, University of Pittsburgh

In giving me the honor of addressing this distinguished society, you have selected a very appropriate city, Montreal, as I am in the field of research developed through the influence of a Canadian, Dr. Robert Kennedy Duncan. Dr. Duncan was born and raised in Brantford, Ontario, received his education in Canada and the University of Toronto, and came to the United States to teach us how to educate industry to appreciate the value of science. In March, 1911, Dr. Duncan inaugurated the Industrial Fellowship System at the University of Pittsburgh in the Department of Industrial Research, known since 1913 as Mellon Institute of Industrial Research. The system was first established at the University of Kansas in 1907, and the two units were united in Pittsburgh in 1912. It represents a sane, practical plan of coöperation between industry and learning for increasing the efficiency of American manufacturing. The success of the Institute today is due to the sound fundamental principles established by Dr. Duncan.

The present home that we occupy was completed in 1915. It was started by Dr. Duncan. Unfortunately he never lived to see it completed. When we moved into the new building in 1915, there were 21 Fellowships in operation, employing 32 Fellows, and industry was contributing $61,200 a year for the support of the work. On February 28, 1930, at the close of the Institute's fiscal year, there were 61 Fellowships in operation, employing 142 full time Fellows, not including a number of assistants and permanent members of the organization, and industry contributed $929,109 for the support of the work. We have completely outgrown our present quarters. You have probably noticed the press reports of our new temple of science which will be erected in Pittsburgh to house properly the Fellowship work of the Institute. Construction work will be started early this Fall.

The nation-wide increase in research, as evidenced by larger budgets for investigational work, is reflected in the rapid growth of Mellon Institute, one of the oldest institutions in the country organized exclusively for the application of science to technology, and is likewise emphasized in other research organizations. In 1900,

* Presented at the annual dinner of the Society at Montreal, June, 1930.

the number of organizations devoted exclusively to research work in the United States could be counted on the fingers of one hand. There are at the present time over 1,000 well established research organizations, and during the past year industry spent around $235,000,000 for the support of these research laboratories. It is being made clear to American manufacturers that scientific research, properly planned and systematically carried out under conditions favorable to productive effort, is remunerative to them and actually constitutes an investment. We, in our organization, do not derive any profit out of our investigations, and only survive as a result of our achievements. Our position is well illustrated by the boy who was hoeing potatoes in a garden. A man came along and said, "Son, what do you get for doing that?" His reply was "Nothing, if I do, and the dickens, if I don't." That expresses our own position.

It is now recognized by industrialists that the methods of science are the most effective procedures thus far developed for the advancement of technology, and that, therefore, scientific investigation is an essential economic adjunct to manufacturing enterprises. But this understanding of the meaning and value of research has come in quite recent years in these United States, for American manufacturers required demonstration of the economic value of scientific investigation. At present the encouragement of research and the recognition of the desirability of disseminating the knowledge gained are indeed among the most noteworthy signs of progress in technology.

Industrial history makes it clear that happy ideas and chance discoveries have not contributed materially to the progress of technology. The stimulus for development generally results from demand, and in manufactures organized on modern lines the working out of new processes and the improvement of existing processes consist mainly in the application of scientific fact and theory, the raw material of the applied scientist and engineer. Industry, therefore, should sustain pure as well as technical research, not merely for altruistic reasons, but because pure science research makes for progress in technology. This was recognized by President Hoover as a huge national need, while he was Secretary of Commerce, and a campaign was started to raise an adequate fund to support pure scientific research work. The fund has now reached approximately $10,000,000 through the efforts of a strong committee of outstanding scientific men, under the auspices of the National Research Council. It is not only important to hold such capable men in our universities to supply the raw material, pure scientific data, but also to have these men available to develop new talent and to supply industry with the other essential raw material, the well trained research worker.

Industry requires men well trained in the fundamentals of science and most important of all, men who can think, and think clearly. A teacher should be an inspiration to his students and should point out clearly the future possibilities in the field of science, and not teach them in such a manner that the student will get the impression that everything worth while has been accomplished. Dr. Duncan possessed that characteristic to a very high degree. I entered the field of chemistry owing entirely to the manner in which he taught the subject. At that particular time he pointed out to his classes in the most glowing terms the rainbow, at the end of which you would always find a pot of gold, and many of his former students have achieved that distinction. Dr. Redman, another Canadian, and former Fellow of Mellon Institute, is a good example. One of the most important constituents of radio equipment is a chemical product known as "bakelite" or "redmanol," which is manufactured from two common substances, namely, carbolic acid and formaldehyde. Dr. Redman has played a most important part in evolving the technology of the phenol resins. Beginning with the discovery of a proper method of controlling the production of these phenol resins, their subsequent hardening under heat and pressure, and their increased strength when fillers are used, particularly fibrous fillers, all this has made possible their application in technology in the widest and most varied manner. It has made possible the rapid and cheap production of distributor heads and rotors for automobile ignition. The accuracy of dimensions with which these phenol resins can be molded and their permanence of shape under elevated temperatures, such as one gets under an automobile hood, have made their application very extensive in the automobile industry. They become coil housings, bells for motors, insulation strips, and punchings of all sorts and varieties in the automobile today. Also, the timing gear in many automobiles is made of laminated canvas-base phenol-resin material.

Phenol resins are rapidly changing the grinding wheel and waterproof sandpaper industries and bid fair to revolutionize completely the method of oil-well drilling, since carborundum, held together with a phenol resin, cuts through sand many times more rapidly than steel bits.

Some of the more spectacular and less voluminous uses created for phenol-resin products are dentures, non-heat producing grinding instruments for the dental trade, glaze for porcelain ornaments, handles on coffee percolators, pencil barrels and fountain pen barrels, beads, buttons, billiard balls, and pipe stems.

Chemistry, the eldest of the experimental sciences, has contributed a great deal to the development of research, but it remained for economics to show the need for and value of industrial research.

As early as 1890, the opinion was expressed in England and on the continent by chemists who reviewed the trend of developments in their science, that the greatest advance in future years would take place in America. Although European countries stood in the forefront at that time, it was felt that conditions were such in America that we were destined to take the lead at a not distant date in both industrial and scientific achievements. This prophecy has to a large extent been fulfilled. For many years the German chemical manufacturer was far in advance of those of all other nations in recognizing the utility of industrial research; but during the past decade American technologists have assumed leadership in employing highly trained chemists and other scientists in original researches with a view to new discoveries or to useful improvements. The United States now has the largest chemical industry in the world, and this position has been attained through coöperation between aggressive capital and creative science. This type of research coöperation reduces to a minimum the time elapsed from the discovery of a principle in science to mass production. The electrical industry, which is based upon the pure science research of Michael Faraday, required nearly a hundred years for its development. Compare with that the development of the radio industry or any of our other modern branches of manufacture during this period of better understanding of coöperation among the pure science research worker, the industrial scientist, and the industrialist.

The round-the-world cruise of the Graf-Zeppelin was made possible through scientific coöperation. The past decade has witnessed the rapid rise of a new branch of the organic chemical industry, and two of these products were used to refuel the ship. Ethane was used to refuel the Graf-Zeppelin in its recent trip to this country, and we supplied its fuel requirements by shipping propane to Japan and California for the world cruise. In Japan a hydrogen-propane mixture (one-third hydrogen) and in California a natural gas-propane mixture (50–50) were taken on by the ship.

The rapid development of chemical research has made progress necessary in many other fields. The automobile is a good illustration of this fact. If we stop to think, we shall realize that all the resources of a vast and complex civilization have been called upon to produce the car of today. The motor-car industry not only has taken full advantage of the possibilities of its own research organizations, but its spectacular expansion has given impetus to other classes of industrial research, such as petroleum products, rubber, metals, leather, synthetic fabrics and compounds, as well as road materials.

Until thirty years ago, petroleum was important to civilized man chiefly because it was his main source of light. Kerosene lamps

are still widely used in the Orient and the other far places of the earth. Here, however, we get our light by more efficient means and use the petroleum to supply another vital need, a fuel for our automobiles. Studies in the cracking of oil have doubled the available supply of gasoline and promise methods for completely converting crude oil into motor fuel with a little by-product coke. Motor fuels with anti-knock properties have been developed. We hear a great deal about the possible exhaustion of our petroleum resources, and this is one of the reasons for the maintenance of chemical and physical research on petroleum production problems, to provide for such an emergency. This has created a new field of research for the engineering profession. Many scientists have been employed in the refining field, but the production of crude oil, until recently, had changed very little from the first methods used when oil was discovered in Pennsylvania. Great advances have been made in the location, production and transportation of crude oil, since science has been applied to this branch of the industry. The Germans are now concentrating on the production of heavy oils from coal, and have made sufficient advance to enable them to construct a unit of commercial size. It is rumored that Germany will be able to produce sufficient motor fuel to meet its own requirements.

The rubber used in the automobile tire has likewise developed some of our largest corporations, and one has only to recall past experiences with an automobile tire and then think of the present-day product to appreciate the advances that have occurred in this industry through the application of science. The service life of tires has been greatly increased, thanks to research on accelerators for vulcanization, on rubber compounding, and on the tire fabrics.

Progress in other and related fields not so well known has been equally rapid. The automobile has completely revolutionized the paint and varnish industry, because of the requirements for a better finish and one that can be applied in a short period of time. The result is the manufacture of nitrocellulose lacquers, and the development of new synthetic gums and solvents. This, in turn, has created two entirely new industries within the last ten years. One of these industries is located in the corn-belt area of Indiana and Illinois. Through scientific research in the field of biochemistry, the corn is treated with a new type of microörganism which produces these necessary lacquer solvents instead of the familiar solvent, ethyl alcohol. The second of these industries depends upon the common product, natural gas, for its source of raw material. This industry is especially close to us, as it originated and was nurtured into adolescence in the laboratories of Mellon Institute. The results of this research have made available in large quantity and at low cost a variety of commercially valuable organic chemicals,

distinct in origin as well as in application from the synthetic chemical products heretofore generally known.

A principal product of these efforts is ethylene glycol, which has come into commerce for the first time, after having been known since the early days of chemistry only as a curiosity. Ethylene glycol is now widely used in explosives manufacture and as an anti-freeze material for automotive engines; it is also finding numerous new uses to supplement the inadequate supplies of glycerin and is serving purposes entirely new in the arts. The ethers of glycol are ideal solvents for nitrocellulose lacquers, and in the rapidly expanding lacquer industry they are introducing indispensable qualities.

The pure hydrocarbon constituents of natural gas have also found many valuable and interesting uses. For example, ethane, propane, isobutane, and normal butane have been found to possess special physical properties that make them desirable as refrigerating gases. Commercial propane, distributed in cylinders, is a fuel gas with widespread application in the household, laboratory, and factory. Thus, ever more products are being made from natural and other gases, and it is apparent that an industry of large proportions is in the process of being established on the fundamental research that has been conducted in this field.

The electric illumination, radio, electrochemical and telephone industries have been developed from their basic inventions to important places in our present industrial organization in a period of less than fifty years. In each there is striking evidence of the interrelation of the "cycle of research" with the various stages in the evolution of the industry. It is significant that the time lag in the development of these industries has been greatly reduced by systematic scientific research. What happens when research is undertaken in older industries—in the iron and steel industries, for example, which are of the oldest in recorded history? The steel industry for hundreds if not thousands of years was an art, and yet within less than 50 years it has felt the influence of research and has experienced a greater development in that period of five decades than in all the centuries that went before.

Another very important manufacture that has been due mostly to chemistry is the byproduct coke industry. Modern civilization rests largely upon coal and iron, which, in turn, are linked by coke. In making coke, other materials, termed byproducts, are had, from which modern chemistry has developed thousands of indispensable chemicals, fertilizers, explosives, disinfectants, perfumes, roofings, wood preservatives, medicines, and practically all the dyes used in the textile industry.

Naturally, one of the main subjects of research is coke itself. Not many years ago, the coke made in the wasteful bee-hive oven

was preferred by the average blast-furnace man. Now it is generally recognized in American practise that byproduct coke gives superior results. This has been due not merely to a change of attitude on the part of the blast-furnace man but to a real improvement in the quality of the byproduct coke; and research is in progress for further improvements of interest in blast-furnace practise. Frequent investigations have to be made in relation to producing the best possible coke from new types of coal. These coals must be studied both in the laboratory and in the plant, in order to determine the conditions best adapted to each. The conditions satisfactory for making coke from one kind of coal may be quite different from those necessary in dealing with a different type. The results of these investigations are of the utmost importance from the standpoint of fuel economy and conservation.

Coal is one of our most important raw materials, and offers many opportunities for research work both from the chemist's and engineer's viewpoint. In the field of engineering and physics, heat insulation in all its varied aspects has a great future, since it has recognized value in reducing working expenses, and specifically it is of very material aid in effecting fuel economy. It is recognized generally that the losses from bare pipes and boilers are considerable, but the real magnitude of these losses is little appreciated. The fact that the loss from 1,000 sq. ft. of exposed surface at 100 lb. per sq. in. steam pressure represents over 300 tons of coal annually is a sufficient justification for the serious consideration of the subject. Valuable research has been conducted in this field during the past few years, which has placed the industry on a scientific basis and has created more efficient, durable and serviceable insulation. The proper amount of non-heat-conducting material which should be applied to any heated surface will be that at which the cost of an increment of the covering will just balance the savings that will be accomplished by the increment. All insulation companies are now in a position to supply such information as a result of careful scientific research work.

One of the biggest problems that we are facing is the smoke nuisance. Smoke does not have a single saving grace. It is injurious to health. It is expensive in that it means fuel waste, high laundry bills, defacement of expensive buildings and lessened working capacity. Experts declare that throughout the United States smoke costs each inhabitant $16 annually. Smoke is not, as it was once thought to be, the inevitable consequence of industrial and commercial activity. Modern power plants do not smoke and neither do privately designed heating plants in capable hands.

The remedy is to provide such engineering oversight of new installations as to insure a non-smoking plant to begin with. This

can be done. It may mean changes in building plans, a larger investment, a greater responsibility of management, a more intelligent operation, but these things are the price of clean air. It is of little use to complain of smoky stacks and allow new ones to be added daily.

Along with coal, we have another most important raw material in cellulose. An enormous chemical industry has been constructed on the use of this raw material, including lacquers, explosives, celluloid, sausage casings, and last but most important rayon. Rayon, born of chemistry, is now an important factor in the textile field. Many manufacturers are at present making all-rayon fabrics, while others are combining rayon with cotton, silks or wool. About one-fifth of the hosiery produced today contains rayon; millions of yards of cloth are being made annually, either wholly or in part of rayon. Cellulose is also the basis of another new industry developed in the chemical laboratory, the artificial sausage casings. One hundred miles a day of these casings are now produced to cover our well known "hot-dogs." As is so often the case in the synthetic production of a new product, new properties are introduced which give added value to the material. It is possible to remove these synthetic casings from the meat—after the stuffing process—and the finished weiner is sold as a skinless product.

Someone has said, "the sugar industry without the chemist is unthinkable." This statement is indeed correct, for chemistry has been the main factor in the development of sugar technology. Agriculture, manufacture, refining and uses have depended upon chemistry in this important industry; and the many processes the chemist has worked out have brought better, cheaper sugars and growth to all branches of the sugar producing and consuming manufactures.

The manufacture of glucose and grape sugar, or the corn products industry, was built upon a notable discovery of a chemist, namely, the conversion of starch into reducing sugars. Since then—over a century ago—chemistry and chemists have been inseparably and intimately connected with this great industry. Chemical research has shown how to make profitably corn syrup, starches, dextrins, many gums (for adhesive purposes), various sugars, gluten feed, oil, oil cake, and other products from corn. The chemist, in fact, has found the way to manufacture over one hundred useful commercial products from this raw material, the fruit of a majestic, wondrous plant.

The problems that are now receiving the most attention in Europe as well as in the United States are the fixation of nitrogen, coal liquefaction, gas supply, dyestuffs, synthetic organic chemicals, principally solvents, and textiles, including artificial silk. In

Europe most of these problems are related to and depend upon coal or lignite as a raw material. From coal can be made synthetic ethyl alcohol, methyl alcohol, other organic solvents, and hydrogen for use in the nitrogen fixation process for the manufacture of ammonia, besides dyes, medicinal products, motor fuels, and fertilizers.

The countries of Europe are also combining forces in the development of these various industries. This type of coöperation cannot help but bring important economic results, and yet it is only one part of an effort to gain industrial and independent recognition.

Europe realizes that scientific coöperation is the most powerful means of dealing with many of the economic difficulties with which it now is faced, and the surest means of self-protection and preservation. This is also regarded as true in all well-organized business enterprises of today. The aim of business is profit, and hence it is essential to operate plants with gain. In consequence of this recognition in industry, incumbrances that interfere with advantageous production must be discarded. Waste, inefficiency, senile processes, antiquated plants, and unscientific practises in general are the foes of profitable operation. Effective intelligence service on market conditions, both foreign and domestic, and adequate technical research on plant production problems are the agencies upon which the dynamic, successful business of today is most dependent.

Today's strenuous competition most influences progressive change or improvement. It has brought respect for industrial research, simplified practise, efficiency programs and statistics. Paradoxically, associated effort has effected beneficial contact among competitors and has enabled concerted vigilance, fact-finding, and progress in technologic and market research.

It has become a truism to say that scientific research has exercised a profound influence on industry, particularly upon the character and direction of manufacturing methods. It is equally true that industry has had a great influence upon scientific research. By providing opportunities, industry has led to the improvement and extension of research procedures.

Business is being conducted on a wider scale and at greater speed than ever before. This makes it hard for the weak and inefficient manufacturer, but opens a wonderful vista to those who are strong, able, free from over-worship of precedent, and appreciative of the possibility of improving on the methods of the past. Modern business therefore is especially receptive to the application of science in the correction of production, advertising and sales troubles.

Formerly, throughout much of industry, the voice of the scientist

was that of one crying in the wilderness. Now he commands the respectful attention of the man in the street, as well as of every manufacturer.

If one attempted to appraise the value of science in dollars, the figure would be inconceivably large. Science can best be measured, however, in terms of human achievement, the mastery of the forces of nature, the elimination of poverty and disease, the prolongation of life, the advancement of learning, the growth of right living and sound thinking, and of good understanding among men.

But for all of the benefits that she has conferred upon the world, science asks only that she be provided with an opportunity for her faithful workers to multiply their efforts in behalf of humanity. Pointing to the past, she holds forth with certainty the promise of further greater truths and their developments, new agencies for the comfort and convenience of mankind.

THE ENGINEER AND FINANCE

By WALTER WILLIAM COLPITTS,

Consulting Engineer, New York City

It always gives great pleasure to graduates of McGill to return to their Alma Mater for any purpose, but it is particularly pleasing to come back as a guest of the University to attend a function of such importance as a meeting of the Society for the Promotion of Engineering Education. It is also a matter of great satisfaction to me to be one of those to welcome to McGill the delegates from that great school, L'Ecole Polytechnique de France. Indeed that opportunity is furnished us entirely too infrequently.

As engineers you have all had the experience, no doubt, of seeing the source of a great river, and have followed the tiny trickle as it wound its way through the mountain gorges and out onto the plains, augmented by streams from other sources, growing larger and larger until it becomes a mighty river and a main artery of commerce.

The engineering profession might be likened to that river. Its genesis was in the work of a few men who built bridges, took a little ore from the ground, or planned engines of war. Down the ages, as civilization advanced, they gained a little in knowledge and scope, but it was war that gave them their main opportunities. The stream was still small until the advent of the railroad in the early part of the nineteenth century, and it was in the great events of that period that the civil engineer, as distinguished from the military engineer, was born. Then indeed, in the early stages of the development of our great natural resources, the stream became a small river, and now in the twentieth century with almost every sort of undertaking turning to the engineering profession for advice and counsel, the river has become a mighty torrent carrying civilization along at tremendous speed.

In fact, the word "engineering" has come to stand for so many types of activities that even members of the profession are astonished at the multitude of them. From the grand old profession of military engineering, the daddy of them all we have branched out in every direction. In Canada and the United States, perhaps more than in any other countries, we have come to rely so much upon our engineers that they are now carrying a tremendous load of responsibility that steadily grows heavier. Almost every large busi-

ness to-day avails itself in some manner or other of the trained assistance to be given by the members of our profession in the solution of their technical problems.

The growing relationship between engineering and finance is, I think, the latest development of all, but the difficulties in the way of bringing about such a relationship have been very great and progress has been slow, I think, largely on account of the attitude of the engineer in failing to gain a knowledge of the principles which govern business.

Prior to the time when we began to build our railroads, practically all great works were built by governments, financed by governments, and conducted by military engineers. There were no problems of economics such as we know them today. Financial problems had to do principally with answering the question as to how the money could be found to carry out a project, and the usual solution was to levy an additional tax on an already overtaxed people.

Even as late as fifty years ago people generally would have said that there was no closer relationship between engineering and finance than between the trade of the carpenter and the business of the money lender, and in the intervening period, indeed until very recently, the paths traversed by these two great professions, engineering and finance, have been quite divergent.

I well recall an experience of my own when, as a young man, I was the chief engineer of a western railroad, which was largely owned in England. After giving considerable thought and study to the company's financial condition I became convinced that the president of the company himself did not realize that drastic measures must be taken to avert a receivership. I broached the subject to him and in particular stated my belief that unless we were extremely careful there would not be sufficient funds to pay the forthcoming installment of interest on the bonds. To my utter astonishment I was threatened with decapitation and told never to undertake to discuss a financial problem with him again; that I would do well to confine myself strictly to my engineering work because he had never known an engineer who knew anything whatever about finance.

The sequal to that experience is interesting and to the point. The road was thrown into a receivership and I resigned my position and joined my present partner in the establishment of an engineering firm in New York. The British interest in the road was finally placed in my hands to dispose of in any manner that I saw fit, and after several years of nursing the road was finally sold to a western trunk line for a good round sum.

As a matter of fact, I think the engineer of the past came by his reputation for being devoid of financial sense quiet honestly. Many

of the great fortunes of the country, as well as many of the great industries upon which our present day civilization rests, are the product of his brains, but the translation of his ideas into profitable business enterprises has mostly been the work of others. And the reason for this is plain. The engineers of an earlier day, and to a large extent of this day, were engaged in work that removed them far from contact with men who know anything about financial affairs at all. The technical work for which they had been trained absorbed their entire attention. Even those who were fortunate enough to have had a college education had not been initiated into the mysteries of finance and they were quite uninterested in the subject. They were admired by the men in whose hands the financial problems of the enterprise were placed for their willingness to undergo hardship without complaint, to find ways across the trackless prairies and through seemingly impassible mountain ranges, and for their cunning in turning the forces of nature to the uses of man; and I have often wondered why in all these years so few engineers have aspired to themselves promote the enterprises that depended so much upon engineering skill. We have been inclined to feel that financial acumen is only another name for a highly developed bump of acquisition, and as a consequence we might be likened to the cooks who are not invited to eat the excellent dinners they prepare.

Perhaps the shortcomings of the engineer in this respect are due to the fact that as a young man his work of necessity is confined to the technical phases of the enterprise, while the financial problems are solved by older heads, and perhaps also the business phases of the enterprise on which he is engaged do not interest him. He likes to deal with the forces of nature because nature always plays fair. Under the same circumstances nature invariably performs exactly the same. She never deceives and the engineer can always take her at her word. She never dissembles, compromises, bargains, or trades, and she always pays in gold coin. And so I think the engineer, in the course of his professional work, learns very early to take nature at her face value, and quite properly so. But my experience in the realm of business leads me to believe that if financial transactions were conducted on the basis of face values there would be many more sorry people in the world than there are, and engineers, I believe, are as well, if not better, equipped than any others, if they would apply themselves, to display the lights on financial shoals.

Yet I have known engineers to conduct their work with most painstaking care and to leave no stone unturned to insure the construction of a safe and adequate structure and then, without any investigation whatever of the merits of the business itself, to accept

pay in securities which later turned out to be worthless. I have done it myself, and without pointing any accusing fingers I fancy a good many of you have done the same thing.

Engineers are analysts by training, and both in the design and erection of engineering works of all kinds are required to practice the art of the diagnostician to a marked degree. The engineer is continually observing the relationship between cause and effect and acting upon his conclusions with a sure step. To my way of thinking, his training and mental makeup are most valuable equipment when devoted to the solution of business and financial problems, and I feel quite strongly that the more general extension of his work in these directions will not only be of advantage to industry and the public generally, but will tend markedly to further his own interests.

As a matter of fact, there are few business problems that escape solution under reasonably accurate analysis, and if the analysis is carefully conducted, without bias, and if full weight is given to each element of the problem, it is astonishing how correctly a future course of action may be charted. Nowadays business is largely run by charts. Future trends, the bearing of one factor on another, the time when certain actions should be taken, all can be foretold from properly constructed charts. The business executive no longer has to guess what course he should pursue; to a very large extent his charts, prepared by unbiased analysts, are his guide. But charts are the engineer's middle name and he is schooled in his technical work to be unbiased. Having the technical training which enables him to know what is practicable and what is impracticable from the physical standpoint, and being familiar with the processes of deduction which are used in engineering investigations, he should be readily able to adapt this knowledge to business investigations and so serve his employers or his clients in a dual capacity, and serve himself in the investment of his own funds, in which latter respect he has in the past been woefully deficient.

My contacts in the business world lead me to believe that there are distinct signs of a tendency on the part of business men to utilize more and more the experience and knowledge of the engineer in the solution of purely business problems. The old trial and error methods of starting new businesses and of conducting old ones are gradually giving way to the far more logical method of careful investigation. The large banking houses in Canada and the United States are learning from experience the value of full engineering advice concerning the projects they contemplate financing, and this advice pertains not only to the physical elements involved but extends to the question which is most important from the standpoint of the investor—that is its merits as a business

undertaking. The growing demand for engineering service of this character furnishes the opportunity for widely extending the field of usefulness of the engineer in directions which a few years ago would have been considered wholly illogical.

May I say a word about the character of my own practice to indicate more specifically the trend of the relationship between engineering and finance as we see it in our own shop? The work of our firm, as well as that of other firms similarly engaged, is ordinarily of a confidential nature, and therefore I will refrain from using the names of corporations or individuals. Although the work of other firms is also largely confidential, we sometimes find it necessary to know what they are doing. Nevertheless, I don't suppose I would be justified in speaking of the work of our competitors. In discussing our work I should first explain that every member of our firm, and practically every member of the staff, is an engineer by training and experience.

We are truly amazed at times at the variety of problems that are brought to us, problems that on their face would seem to have no relationship whatever to engineering. For example, we once helped a theatrical company to decide what it should do about the movies, and in another case we were asked by a movie company to advise what it should do about the talkies. It was left to us on another occasion to decide whether a chain grocery company should go into the candy business.

We have been called upon to help foreign governments with their physical and financial problems. We have taken railroads through trying periods of their development. In one case a large railroad company that was in serious financial difficulties was saved from receivership through the position we took, after thoroughly studying the circumstances, that the company would respond to sympathetic treatment, and it is now a prosperous road. We have made surveys to determine why the selling policies of companies manufacturing specialties did not produce more satisfactory results. We have studied the problems of a great variety of other businesses—sugar, steel, public utility, airplane, automobile, and many others.

At the moment we are trying to decide whether a bridge should be built between two cities separated by a large body of water; whether a company owning a large sugar plantation should refine and market its own product; whether the rates to the various docks in New York Harbor are on an equitable basis; whether a railroad on an island in the Caribbean should be built; whether a railroad should belong to one group or another in the plan for consolidating all of the railroads of the United States into nineteen systems; whether a company manufacturing a product in general use should consolidate with the company that furnishes the raw material; and

a variety of other questions. But I think perhaps the easiest question we have ever had to answer is one on which we are now preparing to give testimony before a court. Two large companies are proposing to consolidate and we are asked to state whether, in our opinion, they should engage engineering service in working out the basis of exchange of stocks.

We find in our practice that just as fundamental engineering principles are much the same, whether we are designing a bridge, a building, a dock, a mill, a power plant, or whatnot, the underlying principles of finance are applicable in a general way to businesses of every description.

I think perhaps in our own practice we have rendered as valuable service in preventing our clients from financing unjustified projects as in any other respect. I should say that scarcely a day passes that we do not turn thumbs down on some business venture. We have approved the construction of a number of toll bridges throughout the country, some of them very important structures, but we have disapproved many more than we have approved. In one case, so insistent was the promoter of a small railroad that the project had extraordinary merit that four separate banking houses whose interest he had enlisted asked us for our opinion on its possibilities. How many other engineering firms disapproved of the project we do not know.

I hope I will be pardoned for referring in this general way to a few items in our own practice. I have done so only to illustrate more concretely the width of the band in which the two professions are beginning to function together, and to indicate the extent to which this band may be broadened.

And, gentlemen, I can assure you there is nothing monotonous or dull about the work that is entailed in this growing relationship between engineering and finance. It is a new story every day and the sport of tracking the elusive dollar to his lair in the applications of engineering science to business is at times full of romance.

I verily believe that much of the suffering that has resulted from such extraordinary occurrences as the stock market debacle of last autumn and the business depression which we are now enduring might in large measure have been alleviated by the dissemination of authoritative economic information concerning our principal industrial activities by a permanent fact-finding body composed of engineers, economists, and financiers. I do not say that such things could be prevented by any human agency but it seems apparent now that ignorance of the economic forces that rule over business affairs on the part of a large proportion of the people has been a strong contributing factor in producing the swirls of business sentiment that so often engulf us, and if we are to proceed on a more even

keel in the future it must be through the gathering of more comprehensive data concerning economic conditions that the engineer ought to be well equipped, first, to bring together, and then to read and understand and explain for the benefit of all.

In conclusion, I want to say just a word about the engineering training that is given at McGill. The Faculty of Applied Science under Dr. Mackay, and under Dr. Adams and Dr. Bovey before him, has always maintained the highest standards of education and has kept McGill in the front rank of the engineering schools of the continent. The men who have taken their training here in any department of the university and are now practicing in the United States all can testify to the fact that they put in a good word for themselves whenever they say, "I am a graduate of McGill." It is the proudest thing I am able to say about myself, and in saying it I invariably arouse a note of interest. Through Sir Arthur Currie's wise guidance the university maintains a reputation second to none on this continent, and the fact that so many students from the United States are attending McGill is outspoken testimony of the manner in which the courses given here are regarded south of the border. I am sending my own children to McGill and the one here now is, I think, the most enthusiastic student in the University.

I believe I have never attended a convention that I have felt so responsive toward as I have this one. It seems to me that the proceedings of this evening have been most unusual, most interesting, and should be productive of the greatest good to the engineering profession. I have watched the work of the Society for a good many years, and I have felt that it was broadening the scope of the engineer, and particularly that it was broadening the views of teachers of engineering to the end that our work may become increasingly useful to the public at large. I congratulate you upon a most successful convention.

THE HISTORY OF THE FLEXURE FORMULA *

By H. F. MOORE

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The Historical Importance of the Flexure Formula. Historians are beginning to give tardy attention to the importance of the work of the scientist and the engineer as a factor in human progress. The reason that such recognition has been tardy is not far to seek. The writer of history has generally lived either in an atmosphere surcharged with military and diplomatic interests, or he has been trained only in the so-called liberal studies, and the works of poets, prose writers, artists and abstract philosophers naturally are *the* important things in the world as he sees it.

However, the modern historian probably owns a motor car, his wife has her domestic laboratory equipped with an electric refrigerator and an electric washing machine, and the importance of engineering comes to his attention through the humble back door of domestic operation if not through the dignified front door of his professional contacts. He has made a good beginning towards recognition of the great transformation of human life by pure and applied science, but as yet he has observed mainly the dramatic features of this transformation—the steam engine, the dynamo, the airplane—and has not yet paid much attention to less striking, but equally important, phases of this transformation.

One such undramatic field of development is found in the problems connected with the strength and stiffness of structural and machine parts. No structure however beautiful in design, and no machine however ingenious in its general scheme of operation, can function successfully if it will not carry its load without fracture. An old ruin may be beautiful; a new wreck is *not*, nor is a propped-up beam or arch, nor is a broken car axle. Today scientific advance in the fields which require the use of high temperatures meets its main obstacle in the lack of metals that will withstand the desired temperatures without failure.

The general scheme of designing structural members to carry direct tension or compression has always been practically self-evident. The load which can be carried is obviously proportional to the area of cross-section of the member under load. But when

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flexure-carrying members are to be designed the general scheme to be followed is by no means self-evident. Evidently *span* is a vital factor, and mere area of cross-section is not a guarantee of flexural strength. The ancients failed signally to develop, or at least to record, design methods for beams and girders, and were never able to build structures involving long spans. They developed the arch, which involves compressive stresses, and which is the easiest span-stretching structural member to design by rule-of-thumb methods (and the hardest to design by careful computation), but did not develop the girder. One outstanding reason for this failure was the attitude of disdain for experimentation manifested by the learned world of Greece—a looking down on the "mean and manual labor" of experimentation as something quite beneath the dignity of a scholar and a gentleman. In this connection it is only fair to state that the great Aristotle did not share this contempt, but that Archimedes, the father of engineering, was so affected by it that he adopted an humbly apologetic attitude towards his own great engineering achievements.*

It was not until the time of Galileo that experimentation obtained general recognition as a legitimate instrument to use in the search for truth, and it was Galileo who started the modern study of strength of materials. The development of this study has centered round the development of the common flexure formula $M = SI/c$, to use the symbols of Merriman, the formula familiar, in form at least, to every undergraduate engineering student above the sophomore year. The writer believes that he is making no rash statement when he gives as his opinion that no battle, no treaty, no ecclesiastical council has had a more profound effect on human affairs than has the development of this simple flexure formula.

The Development of the Flexure Formula. The father of the science of the strength of materials is none other than Galileo (1564–1642). He it was who abandoned the Platonic attitude of intellectual aloofness, and who did not disdain to study the art of the craftsman and to use "mean and manual labor" in experimentation. He was lead to an interest in the development of a formula for beams by observing the practices and the accidents in the Venetian shipyards, and he soon saw that the practice of designing large beams geometrically similar to successful small beams was at times a dangerous practice. He then brought out the idea of external bending moment and internal resisting moment (although he did not use these terms) very much after the manner of the modern engineering textbook. He did not grasp any idea of *elastic*

* For a more detailed discussion of this point see *Science* for July 13, 1928, pp. 24–29 inclusive.

Galileo, 1564–1642

The great pioneer apostle of experimentation as a means of apprehending truth. Made the first analysis of the flexure problem, developing the idea of bending moment and of resisting moment, but not noticing the phenomenon of elastic deformation under load.

James Bernoulli, 1654–1705

One of the earliest investigators (though probably not the first) to notice not only tensile strain but compressive strain also in a beam. Developed the idea of the elastic curve and stated that the bending moment at any point was inversely proportional to radius of curvature at that point. Doubted the correctness of Hooke's law, probably because he experimented on materials stressed beyond their elastic range.

Euler, 1707–1783

Developed rather fully the idea of elastic curve as we know it today (although our modern notation is different from Euler's). Developed the idea of failure by elastic buckling, and the Euler formula for failure of long columns.

Navier, 1785–1836

Professor at the French School of Bridges and Roads. The first to give a complete statement of the flexure formula as we know and use it today. The father of modern Engineering Mechanics of Materials and of the modern Mathematical Theory of Elasticity.

deformation. To him a solid was a solid, inextensible and incompressible until it broke. That assumption means uniform distribution of pull all over any cross-section of a beam, with a resultant pull at its centroid. For rectangular beams (and in Galileo's day 95 percent of structural beams were rectangular) this method enables the designer to *proportion* rectangular beams as correctly as does our modern flexure formula, but his method fails when applied to beams of cross-section other than rectangular. However we do well to remember Galileo's success in stating the principle of bending moment and resisting moment rather than emphasizing his failure to develop the laws of elastic deformation.

Some thirty years after Galileo's experiments Robert Hooke made public the statement of his famous law "as the force so the stretch," or, in modern terms, stress is proportional to strain. Robert Hooke * is a very striking and very human figure of the period of Wren, Boyle, and Newton. He has been characterized as the first mechanician of his day and in all his work showed a marvelous skill in devising and handling apparatus, combined with a distinct weakness when it came to putting the results of experimental work into generalized mathematical formulas. His statement of his law was founded upon a frankly experimental basis. In his lecture "De Potentia Restitutiva" (the title is in Latin, but the text is in English) his justification of his law is contained in the following quotation:

> "Now as the Theory is very short, so the way of trying it is very easie.
>
> "Take then a quantity of even-drawn Wire, either Steel, Iron, or Brass, and coyl it on an even Cylinder into a Helix of what number of turns you please, then turn the ends of the Wire into Loops, by one of which suspend this coyl upon a nail, and by the other sustain the weight that you would have to extend it, and hanging on several weights observe exactly to what length each of the weights do extend it beyond the length that its own weight doth extend it to, and you shall find that if one ounce, or one pound, or one certain weight doth lengthen it one line, or one inch, or one certain length, then two ounces, or two pounds, or two weights will extend it two lines, two inches, or two lengths; and three ounces, pounds or weights, three lines, inches, or lengths; and so forwards."

Hooke's law is thus seen to be a law founded directly on observation, and, judged by modern standards, on crude observation. Hooke himself seemed to recognize no limits for the application of his law, and, in fact, was not particularly interested in the *strength* of materials, but rather in their *stiffness*. He developed his law in connection with the use of watch springs, and to him the laws of elastic deflection were of more interest than considerations of elastic strength.

* After several years of search the writer has been unable to find any portrait of Hooke.

Today we would by no means accept a proposed law on such a basis of evidence as Hooke offered in 1678, yet we must recognize the fact that subsequent study and experiment has shaken but slightly our faith in the practical reliability of Hooke's law—within limits.

Hooke noted the stretches and compressions which exist in a bent beam, but took no steps towards the development of a correct flexure formula. With Hooke's law and Galileo's idea of bending moments and resisting moments, the raw material for such a formula was at hand, but the actual development required a period of a century and a half.

In this period of development the first figure to appear after Hooke is Mariotte * (1620–1684). Probably without knowledge of Hooke's work, Mariotte announced the same law of proportionality of stress to strain. He observed the fact that there was stretch in the fibers on one side of a bent beam, and compression in the fibers on the other side. Without any clear evidence, experimental or logical, he stated that at mid-depth of a beam there is a layer which is neither stretched nor compressed, and thus was the first to give the idea of a neutral axis. Much discussion followed between the advocates of Mariotte's picture and those of Galileo's—a discussion which lasted well into the nineteenth century.

James Bernoulli (1654–1705) in 1694 indicated the differential equation of the elastic curve of a bent beam, basing his determination on the theorem that at any point the radius of curvature of the bent beam is inversely proportional to the bending moment at that point. To use this differential relation it became necessary to evaluate various constants, among them the one we now know as the modulus of elasticity. Bernoulli was not able to do this, and it remained for the combined work of Coulomb, Young, and Navier to accomplish this evaluation.

Bernoulli doubted the truth of Hooke's law, probably because his experiments were carried out under stresses well beyond the limit of proportionality of stress to strain. He seems to be the first to investigate the elastic curve of a beam. Varignon (1654–1722) also doubted the proportionality of stress to strain, and wrote a memoir defending Galileo's treatment of the flexure problem, at least to the extent of neglecting the compression in a beam.

An interesting figure in the development of the flexure formula is Parent, who published a memoir in which he reasoned from the truth (now evident enough) that over any cross-section of a beam the total tensile *force* must balance the total compressive *force.* Parent seems to have come to the very threshold of giving a complete

* The writer has been able to find no portrait of Mariotte, of Parent, or of Coulomb.

statement of the modern flexure formula, but his work seems to have been buried for many years, and recognition has come long after his day. We are lead to wonder how many unknown investigators, whose work has never become known, worked out the flexure formula.

The correct location of the neutral axis (better the neutral surface) in a beam became known through the work of Coulomb, whose memoir on resistance of materials was published in 1773. However, his discussion was so condensed that it was not generally understood for some forty years. It is of interest to note that Saint Venant in his historical summary of the early history of the mechanics of materials * states that after the publication of Coulomb's memoir the consideration given to elastic curves, the elastician's problem, grew less, while the emphasis shifted to the problem of resistance to flexure, the engineer's problem. Coulomb's memoir was written as the result of the author's experience in Martinique as a military engineer. Coulomb introduces the consideration of shearing action in beams.

Navier (1785–1836), a professor at the famous French technical school of roads and bridges, is to be given the credit for the final development of the modern flexure formula. In his earliest treatments he made the error, often repeated by subsequent writers, of assuming that for any cross-section of a beam the sum of the *moments* of the tensile forces equals that for the compressive forces—a statement true only for symmetrical sections. Navier integrated the work of Galileo, Hooke, and Coulomb, and used the idea of modulus of elasticity developed in 1807 by Thomas Young. The equivalent of the simple flexure formula is given us by Navier under the name of "equation of permanent cohesion," but he did not use the modern term "moment of inertia," using an integral expression instead. A modern reader of Navier's notes finds the flexure formula almost concealed within a discussion of the nature of cohesion and an elaborate mathematical study of certain elastic conditions.

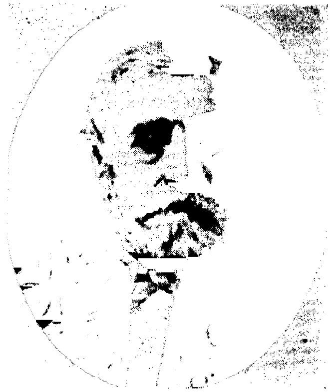
As in the case of Hooke, so to a less degree with Navier the simple, concise, and vitally important contribution which each made to the science of mechanics of materials was not given the great emphasis which it has been found to deserve. This, of course, is a common happening in the development of any scientific theory.

It may be noted that nearly all the mathematical development of the flexure formula was done by workers on the continent of Europe, and it is an interesting fact that some ten or twelve years

* This summary given by Saint Venant, together with a historical sketch by the French engineer Girard, is our chief source of knowledge of the history of the early days of the science of mechanics of materials.

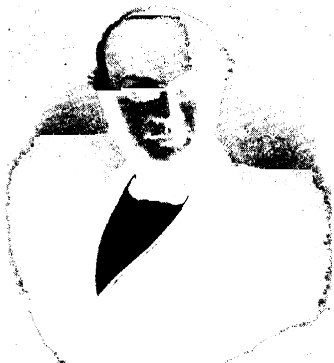
Tredgold, 1788–1829

A representative "practical" British builder who, while not using a correct form of the flexure did noteworthy service in leading builders to consider the use of analytical methods in practical design. Shares with Barlow the distinction of being a pioneer writer of "handbooks" for structural engineers.



Saint Venant, 1797–1886

The pupil of Navier. Developed Navier's work into the modern Mathematical Theory of Elasticity. A man with a mathematical turn of mind, who yet did not lose sight of the necessity of serving the "practical" structural engineer and machine designer.



Weisbach, 1806–1871

The outstanding pioneer in harmonizing mathematical analysis and practical structural problems in Germany. His text on Mechanics of Engineering could be used with good success as a textbook in a present day engineering school.

Rankine, 1820–1872

The outstanding British pioneer in harmonizing theory and practice in engineering work. His textbook on Applied Mechanics has served largely as a general model for texts in English ever since its appearance. He may be characterized as an engineer with a taste for and an ability to use mathematical analysis in his everyday work.

elapsed between the publication of Navier's notes and the general use in England of the correct flexure formula. The English engineers were very "practical" men. Two of them Tredgold and Barlow published working formulas for beams before the appearance of Navier's notes, and these working formulas followed the old erroneous assumptions of Galileo. It was some ten or twelve years later that Barlow corrected his book to agree with Navier. It is also worthy of note that before Barlow made this correction he made a number of rather delicate measurements of strain in beams, finding by direct measurement that the neutral surface was indeed at the centroid of a section. The practical British mind of 1830 preferred to have mathematical reasoning reinforced by experimental study before placing full confidence in it.

An interesting branch line of the development of the flexure formula is found in the work of Euler. Taking Bernoulli's work on the elastic curve he developed its treatment to what is essentially its present form and then applied this line of reasoning to the behavior of long columns under compression, giving us the Euler column formula. This happened years *before* the work of Navier. Engineers have often been puzzled to account for the neglect of fiber stress and strength of material in the Euler column formula. The reason may well be that he developed it as an elastician interested in deformation rather than stress and developed a formula for failure under a very special condition, that of disastrous buckling before elastic failure of fracture occurs; he had no interest in elastic failure or in fracture, only in excessive buckling under elastic conditions. His column formula belongs in a different category from the flexure formula.

Since the days of Navier the development of the science of mechanics of materials has followed two fairly distinct lines; (1) the development of an elaborate mathematical theory of elasticity and (2) the development of a comparatively simple mechanics of the strength of materials used by engineers for everyday computation work. The great figure in the development of the mathematical theory of elasticity is Saint Venant, the pupil of Navier. Many other distinguished elasticians have worked since 1830, but Saint Venant's methods are the outstanding guide for students of that theory.

In the field of engineering mechanics of materials two names stand out, Weisbach and Rankine. Weisbach at the Freiburg School of Mines and Rankine at the University of Glasgow put the essentials of the simplified theory of elasticity used by present day engineers into substantially their modern shape. Today classes in mechanics of materials could be taught with good effectiveness using Weisbach or Rankine as a textbook—in fact up to a very few

years ago Rankine's "Applied Mechanics" was so used in at least one American technical school.

As these two divisions of the science of mechanics of materials develop their fields overlap, especially in machine design, and it seems probable that not many years hence engineering students will be required to become familiar with some of the problems in the theory of elasticity which now are regarded as beyond their reach. It is to be noted also that the students of the theory of elasticity have been mainly interested in the *deformations* of materials, and until recently have not given very careful thought to problems of strength; this means they have been interested in problems of integrated elastic action. On the other hand the engineers have been relatively little interested in deflections and have been greatly interested in *maximum* stresses and strains, a problem of *localized* action. Here again the broadening of both fields tends to bring these two branches of study together.

The Modern View of the Theory of Elasticity. The theory of elasticity uses such elegant mathematical methods that it seems almost a desecration to question its accuracy. Yet when it is to be applied to the behavior of actual materials it is certainly necessary to ask what are its basic assumptions as to the nature of solid materials and how closely the structure and action of the materials used in structures and machines corresponds to these assumptions.

The fundamental assumptions of this theory include the following:

1. Materials are homogeneous,
2. Materials are indefinitely divisible without change of physical properties,
3. Hooke's law holds.

Even a casual examination of the actual materials used in machines and structures shows that the first two assumptions are not rigidly true for actual materials and a careful study of stress-strain diagrams seems to indicate that Hooke's law must be regarded as a very satisfactory approximation rather than a precisely stated law.

About the middle of the nineteenth century the British mathematician Stokes justified the theory of elasticity as applied to metallic materials by showing that the general deformation of laboratory specimens under load coincided very closely with the deformations calculated by the theory of elasticity. As noted previously, it is this general defoımation which is of prime interest to the elastician and such general deformations in agreement with the theory of elasticity would not be at all inconsistent with the existence of many local deformations widely differing from those calculated by the theory. The engineer, interested in the maximum

intensity of strains and stresses at any location, could hardly accept this proof as satisfactory.

Today we realize that the revelations of the microscope and of X-ray crystallography indicate that in any structure or machine part there may exist many localized stresses widely different from those calculated on the basic assumptions of the theory of elasticity and still more widely different from the stresses computed by the simplified formulas which engineers commonly use. Our whole elastic theory, and, of course, the flexure formula which is a part of the statement of that theory, is a generalized, "statistical" statement—a cartoon rather than a picture correct in every detail.

The Value of the Flexure Formula. The recognition of the limitations of the theory of elasticity, and of the flexure formula, in no wise diminishes its value to the designing engineer. For structural parts made of even moderately ductile material the existance of high localized stresses does no appreciable damage, so long as the load is not repeated tens of thousands of times. For material subjected to oft repeated loading it must be recognized that the common flexure formula must be supplemented by some means of computing, or at least estimating, localized stresses—stresses at the root of a screw thread for example. The more elaborate theory of elasticity gives the means of computing some such stresses and various experimental methods, such as the study of transparent specimens under polarized light, the study of specimens made of brittle materials and the study of the development of visible strain lines on metallic specimens, may be used to obtain a very fair estimate of the magnitude of localized stresses.

We may as well recognize that such means, including the use of the mathematical theory of elasticity, are by no means exact, but we have the comforting fact that, in all cases so far observed, even under oft-repeated loading, the strength of the parts has always been found to be greater than that indicated by a study of localized stress by the theory of elasticity, either by the use of mathematical methods of stress-analysis or by any of the experimental methods noted previously. We play safe when we make a careful study of stress-distribution by the use of the theory of elasticity.

The writer is of the opinion that structural engineers and machine designers have sometimes been guilty of formula idolatry. The flexure formula, like every mathematical formula for the strength of materials no matter how elegant, is not to be worshipped, but to be evaluated and its limitations examined. All formulas are to be used wisely and carefully and no friend of the flexure formula need worry about its future importance to the engineer.

ORGANIZATION AND ADMINISTRATION OF THE DRAWING DEPARTMENT *

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In view of the looseness with which the two chief words in the title of this paper are often used, it seems desirable at the outset to make some differentiations which will help in clarifying the suggestions and recommendations to be presented later.

For present purposes we shall use the term organization in two senses, to be distinguished by two modifiers: namely, external and internal. The term external organization will be used to designate that instrumentality which has been created by college or university authority to provide the means whereby certain specific and well-defined results, known as training in engineering drawing and descriptive geometry, can be obtained. This organism, or organization, or "machine," if you will, is to be known here as the Drawing Department, although in this country and Canada, at least a dozen different names are used to identify it which, in some instances, do not give to the organization the prestige and dignity of a drawing department. Size, tradition, and corporate arrangement in a particular institution naturally and materially affect the type and name of the external organization.

The organic or primary purpose of the builders of this external organization should be to create an instrument and conditions that will make it possible to do the assigned work effectively, economically, and in complete harmony with all other units of activity in the engineering college and with other served divisions of the school. A fact never to be lost sight of is that the drawing department is only one organism among several in a smoothly functioning whole, and that it is a servant to all the other organisms in the body politic, however independently it may function in accomplishing its own ideals and purposes.

For the sake of comparison only we have termed this organization known as the drawing department a machine. In spite of its being effective and economical in operation at the time of its construction, a machine is always subject to redesign and reconstruction

* Presented at the Engineering Drawing and Descriptive Geometry Session of the Summer School for Engineering Teachers, June 19, 1930.

as operating conditions change. So too in the case of the machine with which we are dealing. Increases in enrolments, wider range of service both within and without the college, new educational principles, and numerous other factors, have made it imperative that redesign of the external organization be undertaken in numerous instances in the last twenty-five years.

It appears, however, that in no division of engineering education has tradition and name been such a deterrent to the evolution and emergence into a departmental organization of a well classified and definite body of subject material as has been the case in engineering drawing and descriptive geometry. Of the more than one hundred and fifty institutions in the United States and Canada giving collegiate engineering instruction, hardly a third have created a free and separate departmental organization for the teaching of these two subjects which so naturally group themselves together. In ninety-three of the best institutions in this country the ratio is two to three. It is the writer's opinion that another third of these institutions would profit greatly if they too should set up organizations that would function as a complete machine instead of a wheel within a wheel as is now the case. We recognize the futility of such a suggestion in the case of some schools, but where it is at all economical it should be done with alacrity if the institution wishes to capitalize to the fullest the benefits that may be derived from unhampered initiative and well designed internal organization. Numerous reasons may be cited in support of this view. Three are apropos at this stage.

It is an obvious fact, in the first place, that the more limited specialized professional point of view of a major engineering department cannot but have a materially narrowing effect on the drawing division under its jurisdiction. Engineering drawing is not simply mechanical drawing, nor is it drawing in a mechanical engineering department. It is not machine drawing, or architectural drawing, or structural drawing, it is more than any one or all of these. Engineering drawing is the language of engineers. It must be taught as such without the flavor or bias of a restricted point of view. The language is too rich in idiomatic expressions from various mother tongues to overlook the advantages of having representatives of the various tongues on the department staff.

In the second place, it is quite clear, we think, that the broadening and sympathetic influence which we wish the drawing department to exercise on our freshmen can best be imparted by an organization in itself broad because it is composed of men chosen from the several professional divisions of engineering. Interest in this particular phase of teaching is not hard to secure in a department which is free to decide its teaching objectives and the methods

of attaining these objectives. It is well known that quite different schemes must be employed in handling freshmen from that used with upperclassmen.

In the third place, the type of work done in a department cloistered within another major department is likely to become more technical and less educational as pressure of numbers increases. We believe that engineering drawing and descriptive geometry must be put on a plane of high educational value along with courses in mathematics, chemistry, physics and the like, before a department giving the instruction will ever be considered anything but a vocational unit. Formerly this may have been the correct goal to achieve. It is no longer such in the present day list of educational objectives in an engineering college.

Other less cogent reasons for consummating the action recommended wherever feasible will appear later in our discussion.

Reference must necessarily be made at this point to the inner parts and workings of this organism called the drawing department. These inner parts can be best distinguished from the whole by placing them under the heading or classification of the internal organization of the department. It is in connection with the building and functioning of this internal organization that administration enters and becomes the important coördinating and driving force. The writer holds that in spite of all the disadvantages that accrue from incorrect name, from faulty structural make-up, and from traditional placement of the drawing department the machine can be made to function satisfactorily if its internal parts are well designed and properly coordinated through forceful and intelligent administration. Administration functions best, however, when there is the least of it, as was the case on the proverbial educational log with a student on one end and a Mark Hopkins on the other.

The design of the internal organization, as we have called it, should be strictly the job of the professor in charge of the department; always, of course, with the help and advice of the members of his staff. Effective administration is possible only when those clothed with its authority proceed to establish a working pattern which all may help to fill in. Effective organization must proceed on the assumption that there is to be effective administration, that is, definitely centered responsibility. It behooves us, therefore, to set up some definition of administration that will form a basis for separating these two primary elements in our discussion, in so far as it is possible to separate them, in order to bring out the true functions of internal organization and administrative control and direction.

Administration, as we conceive it, is the animate force or dynamic that puts spirit, purpose, idealism, and direction into the

organization which has been created. It gathers its authority, of course, from the creator of the machine, namely, the college of engineering. It obtains its dynamic and idealism largely from the individual members of the department, however much these members may be unaware that such is the case. This flow of administrative force around and through an organization is quite like the flow of the life blood of the human system in that it penetrates to the extremest detail and returns to its source markedly affected by each cell through which it has coursed.

From the foregoing it is clear, we think, that internal organization and administration cannot be separated from each other practically or rhetorically by any sharp and clear cut line of division. Organization is comparatively permanent, however, while administration may and often does change as the workers come and go. Organization is and should be slow to respond and to adjust itself to the demands of opportunists from within and without; administration on the other hand, is likely to be too quick to react to any will of the wisp.

It will now be in order to state what is conceived to be the primary purposes of a drawing department in terms of specific goals and objectives, toward the attainment of which both internal organization and administration must strive, leaving the reader to determine for himself and for his department in just which element success or failure accrues under the conditions existing in his own institution. It is not hoped or presumed that these observations will fit every current situation. Standardization of departments is not to be sought. No worse evil could befall us than that we should become like casts from a single mold. It should be understood, however, that the ideal department we now have in mind is one the external organization of which is freed from the mothership of any major department of the college and which has been christened what it really is, namely, an engineering drawing department, rather than a department of mechanical drawing, applied mechanics, graphics, or any other cognomen equally incorrect and less fruitful of deserved prestige and clarity. It is of such a department and its possibilities that the remaining sentences of this paper are written.

The purposes or goals of internal organization and administration in this ideal department may be enumerated as follows:

1. The purpose to bring the department into educational and professional harmony with the purposes of the larger unit which it serves, namely, the college or school of engineering and architecture and, in some cases, other served departments of learning.

It is in respect to this objective that failure may easily occur. Independence in action may lead to autocracy in plan and con-

ception. Restricted action may lead to abandonment of plan and idealism. As stated previously, the drawing department must be organized and administered with its compass needle always pointing to the pole of coordinated engineering education. The optimum of success is attained when engineering drawing contributes its maximum to the life of the college in which it exists and to the lives of the students with which it contacts.

2. The purpose to make as effective and efficient as possible all forms of instruction given in the department including recitation, laboratory, and quiz work, by means of:

a. The utilization of proved educational methods such as sectioning of students on some sound basis of selection, elimination of tedious and wasteful employment of instructors' time in recording grades, preparing class exercises, filing plates and other purely clerical work.

b. By close personal contact of the professor in charge with the younger teachers of the department in their daily work.

c. Through proper choice and stimulation of staff personnel.

d. By means of the subdivision of direction and responsibility into the hands of committees under the leadership of active and interested members of the department, and

e, f, g· · ·n, and on. Through numerous tried and untried educational stimulants and devices which fire the imagination of the students and keep the staff on tip-toe.

3. Since the department of drawing deals largely with freshmen students, it should be definitely the aim of the administration and organization to inculcate those personal characteristics and attitudes in the students which are distinctly of the professional rather than of the vocational type. It is doubtful if we should even assume that the product of our class and drafting rooms will be found in any considerable numbers on industry's drafting boards in the future. Observations of the writer indicate that less and less are we training graduates to be draftsmen. Industry seems to be finding its supply in the high schools and vocational schools. In some quarters it is becoming a well established opinion that engineering drawing is not of collegiate grade. One well-known institution does not even teach freshman drawing. We repeat, therefore, that administrators of drawing, through their individual staff members, must replace the vocational point of view and method with professional and educational substitutes. Too much emphasis cannot be placed on this phase of the drawing department's activity in the future. This in turn again requires the employment of high grade professional personnel.

4. Fourth in our statement of purposes should be that of giving academic prominence and prestige to the department of drawing in

fully deserved portion so that drawing teachers may receive salaries and rank comparable with other teachers of the college, and so that they may hold positions of influence on committees and in councils on educational matters. This we believe is coming to pass to a very marked degree in these later years all over the country, but it cannot be attained by any sounding of timbals or blowing of horns; it must emanate from sound and substantial progress within the organism itself, which progress can be unmistakably seen in the results.

5. A fifth goal of organization and administration in a drawing department should be to provide academic opportunity and encouragement to the teachers so that they may advance in educational and professional standing among their colleagues through graduate work leading to advanced degrees in the field of their professional specialization and through teaching schedules that include a course or courses in the department of their specialization wherever this is at all possible. It would appear that this latter procedure has more merit than the present practice in many departments where all the teachers are from one field of engineering practice and confined in their allegiance to the corresponding department.

6. Security and freedom of experimentation and exploitation of ideas and hunches which staff members may have should be made certain through well established and adequate annual budget provisions for the department. Nothing will stifle initiative more certainly in any ambitious teacher than to be told that there is no money to test out the worth of a promising "hunch" or idea. Three to four dollars per student is suggested as a working basis. Much of this can be accumulated through the collection of fees.

7. An atmosphere should be created in the drawing department that will encourage every member of the staff to attach himself to a national organization or association with others that will permit him to present his opinions and suggestions in such a way that they will receive the widest attention and have the greatest influence on those whom it is desirable he should know and be known by. The organization under whose auspices we are now assembled has done much in the past and will do more in the future to raise the status of the engineering teacher and to make his voice effective in the councils of educational leaders. The drawing teacher must not lag in doing his part.

8. Concomitant with the need for a more educational and professional point of view in the drawing department in both organization and administration, comes the call for leadership and direction from the rapidly multiplying junior colleges and the liberal arts and science colleges who are establishing pre-engineering courses. Because of the extremely high local pressure exerted on

these institutions to supply purely local vocational demands, there is little possibility of their progressing beyond the status of vocational training without there being very definite patterns of educational and professional design in the engineering colleges to which they may turn for guidance. The drawing department must know its objectives and the objectives must be so certainly attained by the processes and procedures of the department that an outsider may clearly see their accomplishment and be guided in a very positive way in his application of the demonstrated principles.

Apropos of this bitterly opposed junior college movement in some quarters and equally enthusiastic support in others, it is not out of place to remind administrators in drawing departments that they must more clearly than any others discern the dual purpose underlying the establishments of these institutions. The unhappy lot which has befallen some of them through misguidance and misunderstanding of their dual functions can be laid directly at the door of ignorant leadership. Drawing may be made to function in the so-called terminal scheme of operation alongside the collegiate courses, but certainly it should be taught on a higher plane of academic conception than the trade school ideal if we are to use it in both fields. Of course, this observation applies to other work such as mathematics, English and the like.

Summarizing these somewhat loosely connected observations, we emphasize again that much is to be gained in the standing and effectiveness of more than four hundred teachers of engineering drawing in more than one hundred and fifty schools and colleges of engineering through greater unity and solidarity of outward form and purpose in both organization and administration; that it is desirable to adopt the name engineering drawing wherever possible to capitalize fully the widest professional aspects of our work; that we shall administer and be administered best when we recognize administration as the dynamic leadership in a department to which all may contribute rather that a clerkship or dictatorship to be avoided as much as possible; that there must be specific objectives set up on both the educational and professional sides quite apart from the mere routine of class and drafting room processes, which objectives encompass the academic, professional and material progress of the department as a whole and its personnel as individuals; and finally that prestige, prominence, and leadership in organization and administration are secured in drawing departments in the same way as elsewhere, namely, by the departments knowing their objectives and attaining them through sound procedures that are perfectly clear to even the casual observer.

REPORT OF COMMITTEE NO. 12—ENGLISH, JUNE, 1930

During 1929–1930, your Committee on English has continued the study of first-year English courses for technical students. The material from the schools holding institutional membership in the Society is being organized and classified. Already one division, that of independent (and sectarian) universities, has been completed. Others will follow in due course of time.

The effort of the Committee to arouse group consciousness among English teachers particularly interested in English for engineers has been increasingly successful. A fairly complete list of all those directing the courses in English offered technical students in the United States and Canada which has been compiled is making it possible for the Committee to extend its contacts through personal correspondence, and to exchange ideas on problems of common interest. Projects for the ensuing year include further study of first-year composition, and a survey of the courses in public or oral exposition, and in literature, which are rapidly becoming a part of the training in English in engineering colleges.

The Conference on English at the Annual Meeting, "The First International Conference on the Teaching of English to Technical Students, "made evident that everywhere English teachers have to take into consideration the diverse character of the background of first-year students, and the great variation in the secondary school training in English. One of the most difficult problems is the necessity of converting a group of students ranging from the very poorly prepared to the really efficient into a homogeneous group.

Through the developments in the teaching of English in the technical schools of the United States has come the increased recognition of the value of intelligent, sympathetic training in English composition and of inspiring, dynamic study of English literature which has resulted in a very just increase in the amount of English required and its closer correlation and integration with the whole educative process. Experiments have been made with varying success with combination courses in English and history, or economics, or government, and in a balanced course including English composition, English literature, and public speaking. Special courses in technical writing, in technical journalism, in report-writing, and in the preparation of theses have emphasized the tool value of English composition, while a great variety of courses in literature have been formulated to meet the special interests of technical students. The latest, and at present striking

development in the teaching of English in the United States has been the sudden increase in interest in public speaking and oral composition which threatens to become almost a popular movement.

There is a resurgence of interest on the part of engineering college administrators in the English courses offered their students. Next year for the first time in several schools the English courses for engineers will emerge from "the usual college English courses" and will be taught by an English instructor specially chosen because he has shown sympathetic interest and has been successful in teaching engineers. In some cases, such a man will be put in charge of all the work in English for the College of Engineering. The Committee feels encouraged as to the prospects for the future of English courses for engineers. In the past, the recruiting of young instructors has been one of the difficult problems; but it is hoped that as the courses in English for engineers gain recognition, it may be increasingly evident that there are opportunities in the teaching of English to technical students that will bring rewards in the way of personal satisfaction, professional recognition and advancement that every sincere teacher has a right to expect.

SADA A. HARBARGER,
Chairman

NEW MEMBERS

DRUMMOND, GARRETT B., Assistant Professor of Mathematics, Oklahoma A. & M. College, Stillwater, Okla. E. L. Patterson, G. G. Gladney.

HOLLAND, UBERT C., Instructor in Mechanical Engineering, University of Pennsylvania, Philadelphia, Pa. H. C. Berry, John A. Prior.

JONES, WALTER B., Research Professor of Education, University of Pittsburgh, Pittsburgh, Pa. F. L. Bishop, Nell McKenry.

MATHEWS, RALPH T., Instructor in Mechanical Engineering, Duke University, Durham, N. Car. Walter E. Farnham, Arthur W. Leighton.

ENTROPY CHART

Professor O. K. Harlan of the Pennsylvania State College has completed a temperature-entropy chart for ammonia. The chart is of such large size (about 22″ × 32″) with the values of temperature and entropy plotted to such ample proportions that they may be read directly with great accuracy. This chart permits the reading of all values at once which renders unnecessary the laborious interpolation of values from tables.

One of the noteworthy features of the chart is the fact that zero of entropy is at minus 40 degrees Fahrenheit, a temperature well below the temperatures which are common in practical refrigeration. This is of considerable importance because negative values of entropy are thus avoided and the probability of errors reduced in calculations based upon the chart.

Some authorities have prepared numerical tables for ammonia with zero of entropy at 32 degrees Fahrenheit but as 32 degrees is just the freezing temperature of water and most refrigeration operations are conducted at temperatures below 32 degrees, negative values for entropy for temperatures below 32 degrees are likely to cause confusion and errors in calculations.

The data used by Professor Harlan in making his chart are based upon investigations of the Bureau of Standards at Washington, D. C. These data are recognized as the latest and best available.

Another interesting feature of this chart is a representation of the "dome" in the yet unexplored and uncharted region of the still higher temperatures which, however, are of no practical value at present in refrigeration. It shows very clearly the effects of "wet" and "dry" compression.

This chart is of especial value in connection with the study of the thermodynamics of refrigeration and is the only one of its kind in existence. It is copyrighted by the author.

Each of the multitudinous lines on the chart is drawn through points plotted at close intervals, each point being plotted as the result of a series of many calculations. The whole work is the (product) of months of painstaking effort.

The chart is useful in factory design work of refrigerating machinery as well as in technical class instruction and its field of usefulness is enlarging.

A nominal charge is made that does not cover the cost of production.

SECTIONS AND BRANCHES

The **Middle Atlantic Section** of the Society for the Promotion of Engineering Education held its annual spring meeting at Lehigh University, Bethlehem, Pennsylvania, on Friday, May 2d, and Saturday, May 3d, 1930. Registration was held in the new Packard Laboratory at 1 o'clock Friday, May 2d, and was followed by a most interesting trip to the plant of the Bethlehem Steel Company.

At a dinner held Friday evening in the Bethlehem Hotel, President Charles R. Richards of Lehigh University, Chairman of the Middle Atlantic Section, presided. After some remarks by President Richards, Professor F. V. Larkin of Lehigh, Professor Harry P. Hammond, and Professor Hehre of Columbia, President Richards called the business meeting to order.

Secretary Rockwell read the minutes of the Bell Laboratories' meeting held December 14th, 1929. Charles G. Thatcher of Swarthmore College was elected secretary, to succeed Professor Rockwell and to serve until the December meeting.

A motion was carried that the members of the Middle Atlantic Section be asked to contribute small amounts ($1.00 suggested as the suitable amount) at the present time for the expenses of the section, and that there be no further solicitation until further funds are needed.

Invitations from Director S. S. Edmands of the Pratt Institute and President K. G. Matheson of Drexel Institute, for the December meeting were presented. Motion was carried that we accept the invitation of Drexel for the December, 1930 meeting of the section.

Motion was passed that a committee on resolutions be appointed by Professor Hammond.

The meeting then adjourned.

On Saturday morning, May 3d, at 9 o'clock the members of the section were entertained by a trip of inspection of a number of the buildings and laboratories of Lehigh University.

At 12:30 an invitation luncheon was served in the Packard Laboratory and at 2 o'clock President Richards called to order a meeting in the auditorium of the Packard Building.

The following representatives of industries presented their viewpoints on the recruiting of engineers:

Emerson B. Roberts, Westinghouse Electric & Manufacturing Co.
O. W. Eshbach, American Telephone & Telegraph Co.
E. G. Bailey, Bailey Meter Co. and Fuller Lehigh Co.

M. M. Boring, General Electric Co.
Herbert A. Wottrich, Public Service Electric & Gas Co. (New Jersey).
Grover C. Brown, Bethlehem Steel Co.

There was considerable discussion of these presentations by both the representatives of industry and of the colleges.

The report of the committee on resolutions presented by Mr. Emerson B. Roberts as follows, was unanimously adopted:

Resolved: That the members of the Middle Atlantic Section of the S. P. E. E. wish to express their thanks and appreciation to President Richards and Lehigh University for an interesting and entertaining program, a most delightful luncheon and a well arranged and instructive opportunity to inspect the work and equipment of the University and of the Bethlehem Steel Company.

Committee on Resolutions:

R. L. Spencer, *Chairman,*
T. H. Harrington,
E. B. Roberts

At 5:30 P.M. the meeting adjourned.

Charles G. Thatcher,
Secretary

COLLEGE NOTES

University of Kansas.—Professor F. E. Johnson, head of the Department of Electrical Engineering, resigned to take a similar position at Iowa State College. The position at the University of Kansas is filled by Professor D. C. Jackson, Jr., of the University of Louisville.

Professor H. W. Anderson of the Department of Electrical Engineering will be on leave of absence during the school year for study at the Massachusetts Institute of Technology.

E. F. Kindsvater of the Department of Civil Engineering has resigned to become an inspecting engineer for the Phillips Petroleum Company. The position will be filled by Mr. D. D. Haines of Washburn College, Topeka, Kansas.

Return to the Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

Society for the Promotion of Engineering Education

Date..........................

THE UNDERSIGNED desiring to become a member of

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

hereby agrees to conform to the requirements of membership, if elected and submits the following:

STATEMENT OF QUALIFICATIONS

Full Christian Name and Surname..
Print Last Name First Middle

Mailing Address (Number and Street)..................................

Post Office (City and State)..

Full Title of Professional Position.......................................
(Title) (Department)

Full Name of Institution...

(To be Signed by Two Sponsors)

SPONSORS

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....

ADDRESSES UNKNOWN

If you know the present addresses of the following members, please send them to the Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

David M. Bavly,
Frank S. Beale,
William D. Bliss,
Edward P. Boyd,
F. A. DeLay,
E. L. Ericksen,
Ray Flagg,
W. B. Getchell,
J. B. Hamilton,
Forrest M. Hatch,
Frank B. Lindsay,
Fred Merryfield,
G. I. Mitchell,
V. C. Muncy,
John E. Nicholas,
William A. Oliver,
Jas. R. Schermerhorn,
Edward S. Sheiry,
Earl A. Stewart,
D. L. Turner,
Arthur E. Wells.

FORM MORE SECTIONS!

By R. A. SEATON

Vice-President of the Society

The attendance at any annual meeting of the Society includes only about fifteen to twenty per cent. of the membership. The great distances to be traveled, the considerable expense involved and the time required make attendance impossible for four fifths or more of the members. These members can read in the JOURNAL the formal papers and discussions, but they miss much of the inspiration of the meetings, the personal contacts, and the opportunity to become acquainted with other engineering teachers, to exchange experiences and to discuss teaching problems with them informally outside the meetings. Yet many members regard the inspiration, the personal contacts, and the informal discussions as the most valuable features of the meetings.

These valuable features, now denied to so many of our members, can be made available to them, in large part, by Sectional meetings. Sections already organized include the Kansas-Nebraska, Kentucky, Middle Atlantic, Minnesota, New England, Ohio, and South Dakota Sections. Each of these sections, through its meetings is bringing to its members many of the advantages which otherwise would accrue only to those fortunate enough to be able to attend the annual meetings of the Society. One or more meetings are held each year, in rotation at the various institutions represented in the Section. Distances are comparatively short, auto travel with several passengers in each car is cheap and convenient, and meetings can be scheduled week ends so as to interfere but little with regular duties. Often they can be held in connection with other feature events, such as football games, thus providing a double incentive for attendance.

Members of sections which have been established are enthusiastic about their value. The meetings are well attended, they promote friendly relations between the faculties of the member institutions, improve the quality of engineering instruction, and stimulate interest in the Society. It is worthy of note that most of the institutions within the limits of Sections have an unusually large percentage of faculty members who are members of the Society.

The writer believes there are few, if any, engineering educational institutions in the United States or Canada which could not profitably cooperate with one or more other institutions in holding Sectional meetings. Rules governing Sections are to be found in Article VII of the Constitution, published in the Year Book. The procedure in organizing a Section is simple. The principal requirement is some member with the initiative to undertake the project.

Form more Sections!

NEW MEMBERS

ADAMS, OTTO V., Associate Professor of Civil Engineering, Texas Technological College, Lubbock, Texas. J. H. Murdough, W. E. Street.

AULICH, WITOLD M., Lecturer, Mechanics and Instructor in Design of Hydraulic Turbines and Pumps, Polytechnic of Lwow, Lwow, Poland. F. L. Bishop, Nell McKenry.

BACKER, LESLIE H., Associate Professor of Chemistry, Stevens Institute of Technology, Hoboken, N. J. F. J. Pond, F. D. Furman.

BAILEY, NEIL P., Associate Professor of Mechanical Engineering, University of North Carolina, Chapel Hill, N. C. E. G. Hoefer, G. M. Braune.

BARTON, WM. H., JR., Professor and Head, Dept. of Civil Engineering, Pennsylvania Military College, Chester, Pa. H. C. Berry, Francis P. Witmer.

BATCHELDER, DEAN E., Assistant Professor of Electrical Engineering, Colorado State Agricultural College, Fort Collins, Colo. Fred L. Poole, L. D. Crain.

BAUER, PAUL, Instructor in Mechanical Engineering, Purdue University, Lafayette, Ind. George W. Munro, John W. Geiger.

BRADFIELD, LANDIS R., Instructor in Social Science, Fenn College, Cleveland, Ohio. J. C. Nichols, Samuel Ward.

BROWN, GROVER C., Manager of Training, Industrial and Public Relations Dept., Bethlehem Steel Corporation and Subsidiary Companies, Bethlehem, Pa. M. C. Stuart, F. V. Larkin.

CASTLEMAN, JOHN R., Associate Professor of Engineering Drawing, Virginia Polytechnic Institute, Blacksburg, Va. L. O'Shaughnessy, E. B. Norris.

CLEVELAND, LAURENCE F., Instructor in Drawing, Northeastern University, Boston, Mass. George H. Meserve, Eliot F. Tozer.

CRITCHFIELD, C. LEE, Instructor in Civil Engineering, University of Pittsburgh, Pittsburgh, Pa. J. Hammond Smith, F. L. Bishop.

DAHSTEDT, RUDOLPH T., Instructor in Physics, Fenn College, Cleveland, Ohio. Samuel Ward, J. C. Nichols.

DAVIS, WILLIAM C., Assistant Professor of Electrical Engineering, Fenn College, Cleveland, Ohio. J. C. Nichols, Samuel Ward.

DEVINE, JAMES J., Assistant Professor of Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. G. K. Palsgrove, John G. Fairfield.

DOUGHTIE, VENTON L., Assistant Professor of Mechanical Engineering, Texas Technological College, Lubbock, Texas. J. H. Murdough, J. C. Hardgrave.

DOUGLAS, JOHN A., Instructor in Electrical Engineering, Stevens Institute of Technology, Hoboken, N. J. Frank Stockwell, H. C. Roters.

DU PLANTIER, DONALD A., Assistant Professor of Structural Engineering, University of Alabama, Tuscaloosa, Ala. G. J. Davis, F. L. Bishop.

EGRY, C. ROBERT, Instructor in Machine Design, Purdue University, Fafayette, Ind. John A. Sauers, George W. Munro.

ERNST, GEORGE C., Instructor in General Engineering, Iowa State College, Ames, Iowa. E. H. Willmarth, F. C. Dana.

FABEL, DONALD C., Assistant Professor of Mechanical Engineering, Fenn College, Cleveland, Ohio. J. C. Nichols, Samuel Ward.

FENTON, CHAUNCEY L., Professor of Chemistry and Electricity, United States Military Academy, West Point, N. Y. C. C. Carter, J. W. Barker.

FRANCIS, CHARLES W., Assistant Professor of Metallurgical Engineering, Fenn College, Cleveland, Ohio. J. C. Nichols, Samuel Ward.

FRANKLAND, EDWIN, Instructor in Engineering Drawing, University of Detroit, Detroit, Mich. Jasper Gerardi, C. C. Johnston.

FULLER, LEONARD F., Professor and Chairman, Dept. of Electrical Engineering, University of California, Berkeley, Calif. B. F. Rader, H. B. Langille.

FULTON, W. THOMPSON, Associate Professor of Mechanical Engineering, University of Vermont, Burlington, Vt. J. W. Votey, A. D. Butterfield.

GALLALEE, JOHN M., Professor of Mechanical Engineering, University of Alabama, Tuscaloosa, Ala. Geo. J. Davis, F. L. Bishop.

GAY, HAROLD J., Assistant Professor of Mathematics, Worcester Polytechnic Institute, Worcester, Mass. Edw. C. Brown, Jerome W. Howe.

HALES, VIRGIL D., Instructor in Civil Engineering, Fenn College, Cleveland, Ohio. J. C. Nichols, Samuel Ward.

HANSEN, EINAR T., Instructor in Steam and Gas Engineering, University of Wisconsin, Madison, Wis. D. W. Nelson, G. C. Wilson.

HANSON, THOMAS C., Instructor in Mathematics and Civil Engineering, University of Detroit, Detroit, Mich. Jasper Gerardi, C. C. Johnston.

HARDING, GEORGE H., Instructor in Civil Engineering and Mathematics, University of Louisville, Louisville, Ky. W. B. Wendt, Ruth L. Koch.

HARTENBERG, RICHARD S., Instructor in Mechanics, University of Wisconsin, Madison, Wis. Kurt F. Wendt, M. O. Withey.

HAWKINS, GEORGE A., Assistant Instructor in Applied Mechanics, Purdue University, Lafayette, Ind. C. S. Cutshall, R. G. Dukes.

HAYGOOD, T. F., Assistant Professor of Economics, University of Louisville, Louisville, Ky. B. M. Brigman, Ruth L. Koch.

HENSHAW, CHARLES N., Assistant Professor of Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. J. G. Fairfield, G. K. Palsgrove.

HODGE, WILLARD W., Professor of Steam Engineering, West Virginia University, Morgantown, W. Va. G. P. Boomsliter, C. R. Jones.

HOUCHERS, JOHN M., Coordinator, University of Louisville, Louisville, Ky. B. M. Brigman, Ruth L. Koch.

HUMPHRIES, POWELL H., Assistant Professor of Electrical Engineering, Tulane University, New Orleans, La. D. S. Anderson, C. W. Ricker.

HUNT, LOUIS W., Professor of Chemical Engineering, Fenn College, Cleveland, Ohio. J. C. Nichols, Samuel Ward.

JONES, WALTER P., Associate Professor of English, University of Louisville, Louisville, Ky. B. M. Brigman, Ruth L. Koch.

KEIM, PAUL F., Instructor in Civil Engineering, University of Nebraska, Lincoln, Nebr. Oskar E. Edison, Ferris W. Norris.

KOPP, CHARLES F., Assistant Professor of Mechanical Engineering, University of Detroit, Detroit, Mich. Jasper Gerardi, H. E. Mayrose.

KURZWEIL, ARTHUR C., Instructor in Engineering Drawing, University of Minnesota, Minneapolis, Minn. R. W. French, H. D. Myers.

LANING, WILLARD A., JR., Research Graduate Assistant in Electrical Engineering, University of Illinois, Urbana, Ill. E. B. Paine, J. T. Tykociner.

LEONARD, CARROLL M., Assistant Professor of Mechanical Engineering, Oklahoma A. & M. College, Stillwater, Okla. E. C. Baker, A. Naeter.

LOGAN, CHARLES A., Assistant Professor of Agricultural Engineering, Kansas State Agricultural College, Manhattan, Kansas. F. C. Fenton, R. A. Seaton.

LYON, DANIEL R., Instructor in Machine Work, Pratt Institute, Brooklyn. N. Y. Otis Benedict, John W. Burley.

MALEEV, VLADIMIR L., Professor of Mechanical Engineering, Oklahoma A. & M. College, Stillwater, Okla. E. C. Baker, A. Naeter.

MANN, FRED S., Director of College Relations, New England Telephone and Telegraph Co., Boston, Mass. C. F. Park, R. I. Rees.

MARGOLIS, JOSEPH, Instructor in Chemistry, Fenn College, Cleveland, Ohio. J. C. Nichols, Samuel Ward.

MCILHENNY, ISBELL F., Assistant Professor of Electrical Engineering, Fenn College, Cleveland, Ohio. J. C. Nichols, Samuel Ward.

MILLER, GEORGE B., President, Cogswell Polytechnical College, 3000 Folsom St., San Francisco, Calif. F. L. Bishop, Nell McKenry.

MITCHELL, WILLIAM A., Professor of Engineering, United States Military Academy, West Point, N. Y. C. C. Carter, F. L. Bishop.

MURPHY, LINDON J., Assistant Professor of Engineering Extension Service, Iowa State College, Ames, Iowa. A. H. Fuller, L. W. Mahone.

NICHOLS, MAURICE E., Associate Dean of Engineering, Fenn College, Cleveland, Ohio. J. C. Nichols, Samuel Ward.

OLSEN, JOHN C., Professor of Chemical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. Erich Hausmann, H. P. Hammond.

PALMER, HERALD K., Instructor in Mechanical Engineering, University of Minnesota, Minneapolis, Minn. J. V. Martenis, J. R. DuPriest.

REXION, ALEX, Instructor in Industrial Placement, Fenn College, Cleveland, Ohio. J. C. Nichols, Samuel Ward.

ROBERTS, JEAN M., Assistant Professor of Electrical Engineering, University of Louisville, Louisville, Ky. B. M. Brigman, S. T. Fife.

RUSSELL, CHESTER, Instructor in Electrical Engineering, University of New Mexico, Albuquerque, N. Mex. R. J. Munro, J. H. Dorroh.

SALMA, EMANUEL A., Instructor in Mechanical Engineering, The Cooper Union, New York City. G. F. Bateman, H. F. Roemmele.

SCHMIDT, HARRY P., Instructor in Physical Elements of Engineering, Pratt Institute, Brooklyn, N. Y. S. S. Edmands, E. P. Lambe.

SEARLES, CHARLES L., Chief of Educational Division, Western Electric Co., Inc., Kearny, N. J. J. W. Dietz, F. W. Willard.

SHIPMAN, FRANK M., Assistant Professor of Chemical Engineering, University of Louisville, Louisville, Ky. Ruth L. Koch, B. M. Brigman.

SHREVE, R. NORRIS, Associate Professor of Chemical Engineering, Purdue University, Lafayette, Ind. A. A. Potter, J. E. Walters.

SIMESTER, JOHN H., Assistant Professor of Mathematics, University of Louisville, Louisville, Ky. Ruth L. Koch, B. M. Brigman.

SPRINGER, GEORGE P., Assistant Professor of Civil Engineering, Purdue University, Lafayette, Ind. G. E. Lommel, A. A. Potter.

STEELE, RUSSELL R., Head, English Department, Fenn College, Cleveland, Ohio. J. C. Nichols, Samuel Ward.

STRAUB, LORENZ G., Associate Professor of Hydraulics, University of Minnesota, Minneapolis, Minn. W. E. Brooke, O. M. Leland.

TALLMAN, FRANK H., Instructor in Electrical Engineering, Cooper Union, New York City. A. J. B. Fairburn, Norman L. Towle.

TEICHMANN, F. K., Instructor in Aeronautical Engineering, New York University, New York City. Chas. W. Lytle, Joseph W. Roe.

TOLAR, M. B., Professor of Mathematics, Fenn College, Cleveland, Ohio. J. C. Nichols, Samuel Ward.

TROSPER, RALPH S., Assistant Professor of Mechanical Engineering, University of Louisville, Louisville, Ky. B. M. Brigman, Ruth L. Koch.

UHRIG, L. VERNON, Instructor in Civil Engineering, The Rice Institute, Houston, Texas. L. B. Ryon, Jr., Wm. E. White.

VAN DEN MEERSCHE, ANDRE J., Instructor in Electrical Engineering, University of Ghent, Ghent, Belgium. H. M. Turner, Chas. F. Scott.

VAUGHAN, JOSEPH L., DuPont Research Fellow in English, University of Virginia, University, Va. J. L. Newcomb, W. S. Rodman.

WALD, ARTHUR, Assistant Professor of Industrial Placement, Fenn College, Cleveland, Ohio. J. C. Nichols, Samuel Ward.

WALLIS, CLIFFORD M., Instructor in Electrical Engineering, University of Missouri, Columbia, Mo. M. P. Weinbach, A. C. Lanier.

WARNER, ROBERT W., Associate Professor of Electrical Engineering, University of Kansas, Lawrence, Kans. H. W. Anderson, D. C. Jackson, Jr.

WEINBERG, EDWARD F., Professor of Mathematics, Rollins College, Winter Park, Fla. F. L. Bishop, Nell McKenry.

WINKLER, EDWIN W., Instructor in Electrical Engineering, University of North Carolina, Chapel Hill, N. C. G. M. Braune, E. G. Hoefer.

WOOD, FREDERICK M., Assistant Professor of Civil Engineering, McGill University, Montreal, Canada. R. D. L. French, R. E. Jamieson.

WOODS, BALDWIN M., Professor and Chairman, Dept. of Mechanical Engineering, University of California, Berkeley, Calif. B. F. Rader, H. B. Langille.

ZELNER, OTTO S., Associate Professor of Civil Engineering, University of Minnesota, Minneapolis, Minn. O. M. Leland, Frederic Bass.

114 applications for membership have been received at this time, November 5, 1930. Have you asked your colleague to share with you the benefits of membership in this Society? An application blank is printed on page 259. Have him fill this out and send it together with check for $5.00 for 1930–31 dues to the secretary F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

COLLEGE NOTES

Alabama Polytechnic Institute.—The new Ross Chemical Laboratory building was completed and dedicated in May of this year. It was named in honor of the late Dr. B. B. Ross who had been head professor of Chemistry at the Institute for thirty-seven years and who died only a few weeks before the building was completed. The floor space is approximately forty thousand square feet and furnishes space for offices for the staff, an auditorium, large student laboratories, and a number of private and research laboratories. The service facilities and mechanical equipment are very complete.

A department of Textile Engineering was established a year ago offering four degree courses leading to a degree and a short course of two years. A new Textile Building is nearing completion and a large amount of equipment will be installed during the present semester. The building is 300 feet long by 65 feet wide two stories and basement, of standard mill construction. Equipment for cotton, rayon and silk will be installed and considerable research work will be undertaken.

A new shop building 250 feet long by 50 feet wide is practically finished and will be in use within a month. In addition to office and class room space it provides a plant service repair shop and storage, and the following shops for class work: Auto mechanics, Carpenter and Pattern, Cabinet and Finishing, and Sheet Metal. Some of this equipment is provided especially for students taking the course in Industrial Arts for teachers.

Beginning this year an option in Aeronautical Engineering is offered in the Mechanical Engineering course. About forty students are registered for the option and laboratory equipment is being assembled for the work. Lieut. Volney C. Finch, a retired naval officer, is in charge of the course. Lieut. Finch has had advanced training in Aeronautical Engineering at Massachusetts Institute of Technology and at the Naval Academy, and thirteen years of experience in naval stations much of which time has been spent as instructor at naval air stations and on ship board.

University of Arkansas.—Professor C. H. Kent, head of the Mechanical Engineering Department, has been granted a year's leave of absence for graduate study in the University of Wisconsin and Professor Marshall E. Farris of the Texas Technological Col-

lege, Lubbock, Texas, has been appointed temporary head of this department. Professor Farris is also on leave from his institution.

Last June Mr. J. A. Blackhurst, instructor in Civil Engineering, resigned to go into professional work and Mr. R. C. Wray, B.S., Carnegie Institute of Technology, 1929, C.E., Virginia Polytechnic Institute, 1930, was appointed to fill the vacancy.

Mr. R. F. Richmond, instructor in Drawing and Architecture, resigned to continue graduate work in Architecture and Mr. R. J. Hammond, who received his degree of Bachelor of Architecture from University of Texas in 1929 and his M.S. in Architecture in 1930, was appointed and has assumed his duties.

Armour Institute of Technology announces that: Thomas E. Doubt, Ph.D., Associate Professor, has been appointed Professor of Experimental Physics; Henry L. Nachman, B.S., M.E., Associate Professor, has been appointed Professor of Thermodynamics; Edwin S. Libby, B.S., M.E., Associate Professor of Experimental Engineering, has been appointed Professor of Refrigeration Engineering; Oliver C. Clifford, Ph.D., Associate Professor, has been appointed Professor of Electrical Engineering; Lynn E. Davies, B.S., Assistant Professor, has been appointed Associate Professor of Experimental Engineering; James S. Thompson, Ph.D., Instructor, has been appointed Assistant Professor of Physics; Charles G. Beersman, formerly Chief Designer for Graham, Anderson, Probst and White, has been appointed Associate Professor of Architectural Design; Russell H. Ewing, A.B., LL.B., A.M., has been appointed Assistant Professor of Economics; Joel M. Jacobson, B.S., has been appointed Instructor in Civil Engineering.

University of California.—By action of the Academic Senate and the Regents of the University during the past months the former College of Civil Engineering and the College of Mechanics here have been merged into the College of Engineering. The College of Mining retains its identity as such.

The College of Engineering comprises the Departments of Civil, Mechanical, Electrical and Irrigation Engineering, each with its Chairman. At the present time these chairmen are: C. Derleth, Jr., Civil, who is also Dean of the College of Engineering; B. M. Woods, Mechanical; L. F. Fuller, Electrical; B. A. Etcheverry, Irrigation.

Professor C. L. Cory, formerly Dean of the College of Mechanics, is on leave of absence until January, 1931, due to illness.

C. F. Garland, Assistant Professor of Mechanical Engineering, formerly of the Universities of Colorado and Yale, is a recent acquisition in the division of machine design and mechanism.

Carnegie Institute of Technology.—The following persons have been added to the faculty of the College of Engineering, Carnegie Institute of Technology: James W. Ballard, instructor in Physics, John F. Eckel, assistant, Bureau of Metallurgical Research, George P. Halliwell, assistant professor of Metallurgy, D. Roberts Harper, III, assistant, Coal Research Laboratory, Hervey C. Hicks, assistant professor, Mathematics, Carl L. Jones, instructor, Mechanical Engineering, John C. Kohl, instructor, Civil Engineering, Dr. H. H. Lowry, director, Coal Research Laboratory, Glenn C. McCombs, instructor, Drawing and Descriptive Geometry, Joseph C. Rintelen, Jr., instructor, Chemical Engineering, Edward A. Saibel, assistant professor, Mechanics, George B. Thorp, instructor, Mechanical Engineering, William B. Warren, assistant, Coal Research Laboratory.

Dr. Emerson M. Pugh has returned to the faculty after a leave of absence during which he secured his doctorate in Physics at the California Institute of Technology. Michael S. Schonvizner, who taught in the department of Drawing and Descriptive Geometry last year, has been added to the faculty of the department of Electrical Engineering. Dr. T. R. Alexander, of the Chemistry department, has returned from a year of study and travel in Germany.

Under the direction of Dr. H. H. Lowry, formerly of the research laboratories of the Bell Telephone Company, New York City, the recently founded Coal Research Laboratory is rapidly being organized. Dr. Lowry has secured several members of his technical staff and research work will get under way this fall. The new laboratory is located in Engineering Hall in a new annex on the north side of the building.

A Third International Conference on Bituminous Coal has been announced for November, 1931. President Thomas S. Baker expects to be in Europe this fall in connection with its organization.

Students in aeronautical engineering will soon have the wind tunnel laboratory at their disposal. Final work is being done on the tunnel at the present time.

The department of Mining and Metallurgy is offering graduate courses in metallurgy this fall for the first time. The work will lead to the M.S. and the Ph.D. degrees. Among the eleven students who have enrolled for this advanced work are four lieutenants of the United States Navy. Dr. V. N. Krivobok, who will direct the study, made a tour of European universities this summer in which similar courses are given.

Case School of Applied Science enters immediately upon a development of graduate evening courses as announced by Dr. William E. Wickenden, president. This new field of work, entirely under the direction of the Case trustees and faculty, opens at once

with three courses. However, the Case administration anticipates a gradual growth of the graduate courses until there will be a complete curriculum offered to young men who are college graduates and who desire further study in the late afternoon or evening.

The courses offered this semester include: Advanced Structures by Prof. Fred Plummer; Modern Physics by Prof. Christian Nusbaum; and Oscillating Circuit and Vacuum Tube Theory by Prof. John Martin.

Such graduate courses are not to be confused with the *undergraduate* courses given at Cleveland College. The new department of graduate evening courses under the Case managemnt will accommodate, both in day and evening classes, many men now possessing bachelor's degrees and wishing to continue their education while employed in Cleveland industries.

Columbia University.—Joseph Warren Barker has been appointed to succeed George B. Pegram as Dean of the School of Engineering. Professor Pegram will continue in his capacity as Executive Officer of the Department of Physics and also devote time to research. In the Department of Mechanical Engineering Professor Frank Lewis Eidmann and Associate Professor George B. Karelitz were appointed to carry on the work formerly given by Assistant Professor Lincoln deG. Moss and Assistant Professor Charles W. Thomas.

The Cooper Union.—The current term opened on October 7 with the usual complement of classes. Both Day and Night Freshman classes in Engineering have been chosen from much larger groups taking the entrance examinations than in preceding years.

In keeping with the policy of intensification rather than of expansion, there have been the following additions to the staff: Department of Chemical Engineering, Mr. Allan L. Tarr, instructor in Metallurgy; formerly metallurgist with the General Electric Company at Philadelphia. Department of Civil Engineering, Mr. C. O. Roth, Jr., instructor in Civil Engineering; formerly instructor at Drexel Institute. Department of Machine Design, Mr. M. St. John Bernner, instructor in Mechanical Drawing; formerly of the Engineering Societies Employment Service. Department of Mechanical Engineering, Mr. E. A. Salma, instructor in Mechanical Engineering; formerly with the United Electric Light and Power Company.

Machinery rounding out the equipment in the various departments is reported as follows: Department of Civil Engineering, 300,000 lb. Emery Hydraulic Testing Machine. Department of Electrical Engineering, in the Alternating Current Laboratory,

Three Motor Generator Sets, with Control Panels. Department of Mechanical Engineering, Sturtevant Blower and Test Duct, Forced and Induced Draft Fans in connection with Laboratory boiler.

The Department of Chemical Engineering continues its work for graduated students employed in the industry by announcing a course of lectures on Unit Operations of the Chemical Engineering Industry, to be given by Professor Albert B. Newman, Head of the Department. Over one hundred applications have been received from men employed in the industry, as well as from graduate students in neighboring colleges.

Under the combined auspices of the Departments of Physics and Chemical Engineering, a course of evening lectures on Modern Physics is given this year by Professor Karl F. Herzfeld of the Johns Hopkins University. The first of these lectures was given on October 7 to an audience completely filling the lecture room of the Department of Physics. Admission to this course was supervised, graduation from a recognized college and a working knowledge of the calculus being the fundamental requisites.

On March 3, 1930, the Daniel Guggenheim Fund for the Promotion of Aeronautics made an appropriation of $300,000 to the **Georgia School of Technology,** to establish a Department of Aeronautical Engineering. The new Department opened in the fall of 1930 in a specially designed building, containing a wind tunnel, surge tank, and other equipment for aeronautical testing and experiment.

The course in aeronautical engineering will include four years of college work, based on the regular entrance requirements for engineering students, and will lead to the degree of B.S. in A.E. The object of the course is to train men in aeronautical research and in the design and construction of aircraft.

Iowa State College.—T. R. Agg, professor of highway engineering, has been appointed assistant dean and director of engineering, and is sharing the administrative duties with Anson Marston, dean.

Prof. F. E. Johnson, formerly head of the electrical engineering department at the University of Kansas, Lawrence, took up similar duties Sept. 1. He is filling the position left vacant by the resignation of Prof. F. A. Fish, who because of health, resigned as head of the department to become a full time teacher.

The department of chemical engineering increased its teaching staff this fall by the addition of Prof. F. C. Vilbrandt, who was formerly with the University of North Carolina.

Other new appointments to the engineering staff were: 14 in-

structors, 7 graduate assistants, 2 fellows, and 1 assistant, which with the two full professors, make a total of 26 new appointments. The total number of full and part time staff members, including the Extension Department and the Experiment Station, is 113.

Preliminary enrollment figures indicate an increase of 5 to 10 per cent. in both freshmen and upper engineers.

Iowa State College granted to the class of 1930 engineers the following degrees: 186 bachelor of science, 25 master of science, 17 professional, and 4 doctor of philosophy.

University of Iowa.—New appointments to the engineering faculty include Dr. W. M. Young and Mr. J. L. Potter. Dr. Young had his undergraduate training as well as graduate at the University of Illinois. He comes as associate professor of electrical engineering from the Texas Technological College at Lubbock, where he held a similar position. Mr. Potter received his B.S. and M.S. degrees at Kansas State College and comes as an instructor in electrical engineering. F. T. Mavis was promoted to be associate professor of Mechanics and Hydraulics and R. M. Barnes to be associate professor of Mechanical Engineering. R. R. Whipple was promoted to be assistant professor of Electrical Engineering.

The electrical engineering department has taken over the building formerly occupied by the chemistry and pharmacy departments, which now becomes the electrical engineering building. It is a three story building approximately 160 x 80 feet in plan. Obsolete equipment has been replaced with new so that the teaching and research facilities of the department have been made more adequate. The building has been remodeled and houses the circuits and machinery laboratory (100 x 40 feet), the communication laboratory (40 x 45 feet), the illumination laboratory, the high tension laboratory, the communication research laboratory, the standardizing laboratory, the instrument room, the mechanician's shop, class rooms, offices, and a large lecture room with broadcasting installation over WSUI. Much of the broadcasting of class lectures in English is done from this room.

Plans are nearly complete for the new mechanical engineering laboratories building, for which bids will be called within the next few weeks. This building will embody several new laboratory features, particularly in the arrangement and facilities of the manufactures laboratories.

Work on the extension of the large channels at the hydraulics laboratory has been temporarily halted and probably will not be completed until next summer.

The registration in the College of Engineering showed an eight per cent. gain over last year, which was confined entirely to the upper classes. The accretions by transfer increase each year, being about 40 per cent. greater than last year. These transfers are chiefly from arts colleges and junior colleges in the state, although a few from other technical schools and more distant arts colleges. Of the present sophomore and junior classes 20 per cent. and 17 per cent. respectively transferred to Iowa this fall. The result of these accretions is that the present senior class is 99 per cent. as large as last year's junior class; the present junior class 97 per cent. as large as last year's sophomore; and the present sophomore class 94 per cent. as large as last year's freshman class, notwithstanding 12½ per cent. of the total of these classes were dropped for deficient scholarship.

An unusually large number of students who had completed one or more years of their class returned this fall (owing probably to employment stringency) to complete their courses. These constitute 5 per cent. of the three upper classes, the number of such in the senior class being 10 per cent.

The enrollment of the Engineering Division of the **Kansas State Agricultural College** continues slightly above the one thousand mark. For the year 1929–1930, it was 1090 with prospects for about the same enrollment during the present year.

Relatively few faculty changes have taken place. Professors R. H. Driftmier, R. S. Sink, and W. H. Sanders have resigned, Professor Driftmier to become head of the Department of Agricultural Engineering at the Georgia State College, Professor Sink to go to the University of Wyoming, and Professor Sanders to enter private business. Professor B. B. Brainard of the Department of Mechanical Engineering is spending a leave of absence for one year at the Massachusetts Institute of Technology in advanced study. Professor L. B. Smith of the Department of Architecture is doing advanced work at Harvard University.

Professor R. G. Kloeffler, head of the Electrical Engineering Department, is back on duty after a year of advanced study at the Massachusetts Institute of Technology and Harvard Graduate School of Business Administration.

Since the completion of the new power plant for the college more room has become available for the Department of Mechanical Engineering, and several important items of laboratory equipment have been added including a Diesel engine, a water-tube boiler, and a separately fired superheater.

Lafayette College.—Dean Donald Bishop Prentice, M.A., M.E., has been elected president of Rose Polytechnic Institute, Terre Haute, Indiana. The Dean whose resignation was officially accepted by the Board of Trustees, will take up his new duties in February, after completing this term in his present capacity.

Charles W. Macdougall, Assistant Professor of Mining Engineering, has been granted a leave of absence for one semester to recover his health. During his leave Mr. A. H. Fay will assume his duties.

Former Associate Professor William S. Lohr has been promoted to a full Professorship in the Department of Civil Engineering.

Former Associate Professor P. B. Eaton has been promoted to full Professorship in the Department of Mechanical Engineering.

Mr. D. L. Arm a graduate of Lafayette College in the class of 1930 has been engaged as Instructor in Mechanical Engineering.

University of Maine.—Among the engineering faculty members who attended the annual meeting of the Society for the Promotion of Engineering Education at Montreal in June, were C. A. Brautlecht, Paul Cloke, E. M. Dunham, W. S. Evans and E. H. Sprague.

Earl M. Dunham, of the Department of Engineering Drafting, attended the two-weeks Summer School held under the direction of the Society for the Promotion of Engineering Education at Pittsburgh, Pa.

Mr. Wilbur E. Tomlin has been appointed Instructor in Chemistry to succeed Mr. E. S. Durgan who resigned at the close of the past academic year. Mr. Tomlin holds an A.B. degree from Kentucky Wesleyan which he received in 1926, and is a candidate for a master's degree at Columbia University where he has done graduate work in Chemistry during the summers of 1928, 1929 and 1930. Mr. Tomlin came here from Mattoon High School, Illinois.

Mr. Joseph C. Twinem has been appointed Instructor in Civil Engineering to succeed Mr. W. H. H. Newell. Mr. Twinem is a graduate of Massachusetts Institute of Technology, and studied geology at the University of Wyoming during the past summer. In addition to civil engineering courses he is teaching Engineering Geology, the need of which has been felt in this college for some time.

There was authorized last spring a project which may be of general interest to the readers of "College Notes." This project was an extensive survey of the road materials of the State of Maine, and is a cooperative project between the Maine State Highway Commission, the Coe Research Fund Committee and the Maine

Technology Experiment Station. Its object is to secure as definite information as possible concerning the location, character, suitability and quantity of deposits of sand, gravel and rock. These deposits will be shown on sectional maps, and complete information will be given as to availability and condition of haul in each case. It is hoped that this survey will be useful to the State Highway engineers, to contractors for road and bridge construction, local builders and manufacturers, and owners of quarries and pits or banks of sand and gravel. One of the benefits to be derived from the project will be information concerning the availability of good concrete or highway materials, which in turn will mean a material saving in estimating the exact length of haul to any particular project so that more accurate cost estimates can be made. The suitability of local materials for certain types of construction will help to decide the most economical design to use in every case. Some preliminary work along this line was done by the Maine Technology Experiment Station and published in Bulletin No. 6 entitled "Results of Physical Tests on Maine Gravels, Rocks, and Sands." This bulletin, published in 1924, included the tests upon those samples which had been made at the University laboratories for the previous ten years. The information as therein given does not attempt to give an estimate of quantity or the exact location of the deposit. The present survey will supplement this work and give the facts lacking in this early publication. This work started early in June, and will continue for at least two years. It is believed that the findings of this survey will have considerable geological value, for Maine is most interesting in its glacial geology. At the completion of the field work a complete report, containing many maps, definite information concerning local deposits, and many interesting details about the surface geological formation of the Pine Tree State, will be compiled and published by the Maine Technology Experiment Station. This survey is one of the projects in the present plan of development of the Maine Technology Experiment Station under its Director, Paul Cloke, for the economic development of the State. Prof. H. Walter Leavitt, Secretary of the Station, has direct supervision of the work.

The New Engineering Building at the **Michigan College of Mining and Technology** is nearing completion and is a welcome addition to the facilities of the college, due to a large growth in enrollment. The building will house the Electrical Engineering department, part of the Mechanical department, and the Geology department. The first classes were held in the new Electrical laboratory the second week of the present term. The laboratory is

equipped with new electrical instruments and machines. One new instructor has been added to the Electrical Engineering department, Mr. Abas, who comes to us from the Westinghouse Company. Mr. R. F. Makens is a newly appointed instructor in chemistry, and Mr. D. E. Palmer an instructor in Mechanical Engineering.

The **Missouri School of Mines and Metallurgy** this year experienced one of the largest increases in enrollment in its history, the enrollment going to 598, an increase of 15 per cent. over the first semester enrollment of last year.

Following is a list of Faculty changes:

Dr. C. L. Dake has been granted Sabbatical leave for the college year 1930–1931 and will conduct research work in petroleum geology in Oklahoma and Texas. Dr. Dake spent the summer in the work.

Dr. J. Bridge, Associate Professor of Geology, has taken a year's leave to accept a position with the U. S. Geological Survey, and has gone to Washington, D. C., to enter upon his new duties.

W. L. Bradford has resigned his position as Instructor in English at M. S. M. to go to the University of Minnesota, where he will teach and do work towards his doctor's degree in English.

F. C. Farnham has resigned as Instructor in Physics and has been succeeded by Mr. C. D. Thomas, a graduate of the Kirksville Teachers College and the University of Missouri.

Captain K. M. Moore, for the past five years in charge of Military Science and Tactics, has been transferred to the Philippines and Lt. John R. Hardin has been transferred here to take his place.

Mr. M. W. Shepherd of Berwyn, Maryland, a graduate of the University of Maryland, George Washington University, and doing work toward a doctor's degree at Johns Hopkins, has been appointed instructor in geology, to take the place vacated by Dr. Bridge.

James S. Cullison, who received his master's degree last spring, will remain at M. S. M. as Instructor in the geology department.

A. J. Miles, who graduated in May, will remain also as instructor in Mathematics.

John M. Willson, of the class of '29 and graduate assistant in physics last year, has been appointed Instructor in Physics.

Prof. P. A. Willis has taken a year's leave as Associate Professor of Mechanical Engineering at M. S. M. to accept a position in the Examining Division of the Civil Service Commission at Washington, D. C.

Dr. Eugene A. Stephenson, formerly of Pittsburgh, Pa., where he had an office as consulting geologist and engineer, engaged in

petroleum work, has accepted the position of Professor of Petroleum Production at M. S. M., beginning this fall. Dr. Stephenson's extensive experience in the petroleum field, coupled with a successful teaching record immediately after his college days, assures the school of an outstanding teacher in this important branch, a branch that has been attracting more and more attention in the mineral industry in recent years.

Montana State College.—Mr. Harold T. Nelson, Bachelor of Science in Civil Engineering, 1930, University of Idaho, has been appointed instructor in Civil Engineering.

Merrill R. Good was elected to the Professorship of General Engineering last June. Professor Good assumed the duties of this position on September 1. Professor Good has been associated with Iowa State College for the past six years, and has been assistant professor of General Engineering for the past two years.

Professor E. L. Grant, formerly head of the Department of Industrial Engineering, Montana State College, and now associate professor of Civil Engineering at Stanford, spent the summer vacation in Bozeman.

E. R. Dye, assistant professor of Civil Engineering, was granted the professional Civil Engineering degree at the June commencement of Purdue University. Professor Dye was employed during the summer months as bridge designer for the Indiana State Highway Commission.

The Department of Civil Engineering, Montana State College, in cooperation with the State Highway Commission and the Bureau of Public Roads, held a Road Conference at the State College, in April, 1930. This conference was attended by sixty representatives from the City Engineers, the County Surveyors, the County Commissioners, the State Highway Department, and representatives from the Bureau of Public Roads and Highway Contractors. This first Road Conference was well received by those interested in road construction in the state, and it is planned to hold another conference some time during the present College year.

The forty-third annual meeting of the Montana Society of Engineers was held at the Montana State College, October 3 and 4. Dean W. M. Cobleigh served as President of the Society during the past year, and was succeeded by A. V. Corry, of Butte, in the annual election of officers.

Dean H. S. Rogers, College of Engineering, Oregon State College, was the principal speaker at the meeting. At an assembly of the Engineering Society and students of the College of Engineering, Dean Rogers gave an address on the "General Values of an

Engineering Education." At a meeting of the Society he talked on the subject, "The Social Responsibility of the Engineering Profession."

The University of Nebraska.—Associate Professor Edward Anderson, of the Department of Mechanical Engineering, has resigned his position with us, taking effect Sept. 1. Replacing him in the department, Associate Professor Walter F. Weiland comes to us from the University of Pittsburgh. Professor Weiland is a graduate of the University of Nebraska, 1918, with Master's degree taken at the University of Pittsburgh in 1923. He has taught at Pittsburgh for the past nine years.

Dr. George R. Chatburn, Chairman of the Department of Applied Mechanics and Machine Design, has been relieved of all teaching duties for the current year, on account of his health. The regents have announced his appointment as Professor Emeritus, to take effect Sept., 1931.

Dr. Chatburn has been with the University since 1894, thus having completed 36 years of service. With the exception of one year of this time, he was active in class room work regularly. During the year 1926–1927, he occupied the position of Dean of Men, for the entire University.

Dr. Chatburn's activities in the Society for the Promotion of Engineering Education are too well known to need recounting.

Mr. Harry F. Cunningham has been appointed Professor of Architecture and Chairman of the Department of Architecture. Mr. Cunningham was formerly connected with the Goodhue Associates, in New York City. He also was Professor of Design at George Washington University, lecturer on Architecture at the University of Florida, and lecturer on Theory and Composition at New York University. His architectural practice dates from 1905, and includes work for the Supervising Architect, U. S. Treasury, as well as consulting work in Washington, New York City, Florida and the devastated areas in France.

While a member of the Goodhue Associates, he had charge of re-designing the tower of the new Nebraska State Capitol.

The **Newark College of Engineering** has completed this year a new building given over largely to recitation rooms, drawing rooms and offices. It connects with the former Campbell Hall on the East and with the main Laboratory Building on the South. The building increases the capacity of the College to perhaps 20 per cent.

The Institution opened this year with a total enrollment of

about 462 students in the four branches of Engineering—Civil, Mechanical, Electrical and Chemical. The largest Freshman class in the history of the Institution numbering 175 men were enrolled. It was necessary this year to set up a waiting list as the facilities of the College are being utilized to the utmost. The new building, however, will relieve a congestion which has existed for some years.

The Mechanical Engineering Laboratory of the College has been greatly enlarged, particularly along the line of gas and oil engines of the marine and aeroplane type. The Testing Material Laboratory has been expanded considerably and the Electrical and Chemical Engineering Laboratories have been thoroughly overhauled and new apparatus installed.

Additions to the faculty this year include:

Mr. John A. Weishampel, who is an Instructor in the Department of Physics, received his education in Pennsylvania State College, taking a course in Civil Engineering, a graduate of the U. S. Military Academy at West Point, and took post-graduate work in Aeronautical Engineering in New York University.

Mr. Axel W. Berggren, who is an Instructor in the Department of Chemistry, has received degrees of Bachelor of Art from Columbia College, Bachelor of Science in Engineering and Chemical Engineer from Columbia University.

Mr. Robert W. Van Houten, who received his training at the New Jersey State Normal School and the Newark College of Engineering, graduated from the latter in the Class of 1930 with high honors and is being retained as Instructor in Mathematics. Mr. Van Houten received the degree of Bachelor of Science in Civil Engineering.

Mr. Charles J. Kiernan has been appointed to the position as Assistant to the Supervisor of Industrial Relations. Mr. Kiernan was graduated from the Newark Technical School with the degree of Associate Engineer in Civil Engineering with the Class of 1926, and has been associated for some time with municipal improvement work. Mr. Kiernan's position as Assistant to the Supervisor of Industrial Relations will embrace the placing and supervision of upper class students in the Civil Engineering Department.

Mr. Frank A. Grammer, who is an Instructor in the Department of English, holds a degree of Bachelor of Arts at Lafayette College, and has majored in English and minored in Education and Psychology in that College.

The **New Mexico College of Agriculture and Mechanic Arts** is experiencing by far the greatest enrollment in its history. Especially is this true in the School of Engineering where the number

of students is mounting to a point nearly equal to that of the combined registration of the other schools. This increase came with such unexpectedness that the entire freshman schedule has had to be revised upon a semi-platoon system to take care of the new men. A beautiful new Spanish patio type dormitory for men has just been completed and dedicated. But it is already completely full, as is also the girls' dormitory. Foster Hall, a splendid new building of Spanish architecture, named after an early president of the College, now a resident of Las Cruces, is just being completed and occupied by the Department of Biology, the Extension Department and some of the departments of the School of Agriculture. This building will give only temporary relief. President H. L. Kent is thus being forced to seek additional appropriations to enlarge the physical equipment of the College to greatly augmented demands upon it. On December 31 last, Dean R. W. Goddard of the School of Engineering died as a result of coming in contact with high tension sending circuits of the College radio station KOB. This was particularly tragic as KOB has been started by him as the earliest educational institute broadcasting station, as well as possibly the earliest of all radio stations in the country. From a simple beginning he had developed it into the most powerful of all college stations. Dean Goddard left a place in college and community that can hardly be filled. Dr. James T. Rood comes from Wisconsin as the new Dean of Engineering. Gilbert L. Shew, graduate of Rose Polytechnic, is a newly added instructor in mechanical engineering. The College broadcasting station KOB has had its output raised from 10,000 to 20,000 watts. In order that its sending radius may be increased to correspond, new towers are to be erected. Leased wires for national programs will give the station additional effectiveness.

Northeastern University.—The faculty of the day division has been augmented by the addition of seven new members: Brandon Trussell has been appointed Assistant Professor of Economics; John C. Morgan, Instructor in Coordination; Elmer E. Haskins, Instructor in Mathematics; Norris W. Potter, Jr., Instructor in English; DeLano G. Rice, Instructor in Coordination; Brainard F. C. Hughes, Publicity Department; and Saverio Zuffanti, Instructor in Chemistry.

The Ohio State University.—Students entering architecture and architectural engineering in the fall of 1930 are beginning the new five-year curricula. The usual residence required for the bachelor's degree in these subjects has heretofore been four years.

The lengthened courses give opportunity for electives in general and cultural subjects, as well as for certain additional technical studies.

The University is prosecuting an extensive building program. A building for pharmacy and bacteriology has just been completed, and construction is proceeding on three additional buildings; a high school, to be operated under the direction of the College of Education, a men's gymnasium, and a natatorium.

The School of Mineral Industries, a grouping of the related departments of mine engineering, mineralogy, metallurgical engineering, and ceramic engineering, is described in a 32 page illustrated booklet recently issued. The importance of the mineral industries, opportunities in those fields of engineering, the School's facilities for study and research, entrance requirements of the College of Engineering, student life, and activities at The Ohio State University are major topics. The bulletin has been prepared primarily for distribution as vocational guidance material in the high schools of Ohio.

Enrollment in the College of Engineering this year is 1724, an increase of 90 over the corresponding date in 1929. The freshman class in engineering numbers 524, an increase of 15 over 1929.

Bulletin No. 50, "A Description of the Engineering Experiment Station of The Ohio State University," has just been issued. The purposes of the Station, special laboratories and equipment, facilities of the instructional departments available for research, and the work and accomplishments of the Station are discussed in detail. The appendix lists the Station publications and projects, the research staff, and the roster of engineering experiment stations in the United States and includes the law establishing the Station and the standard forms for cooperative agreements.

The Pennsylvania State College.—The following new buildings have been completed and are now in use: A new Administration Building replacing "Old Main"; a new Mineral Industries Building; a new building for the School of Liberal Arts, and a new and very modern Power Plant.

During the last year there have been added: a new Main Engineering Building; a new Botany Building; a new Dormitory for women; and a new student infirmary.

There are ten additions to the teaching and research staff in the School of Engineering. These include Associate Professor Fred C. Stewart in Mechanical Engineering and formerly of Georgia School of Technology, five instructors, three graduate assistants in the Engineering Experiment Station and one in Mechanical Engineering.

The enrollment in engineering curricula is 1484 as compared with an attendance of 1378 a year ago—a gain of 106.

University of Pittsburgh.—Three new instructors have added to the Civil Engineering staff: A. Diefendorf, former head of the Civil Engineering Department of the University of New Mexico, as Associate Professor; Edgar D. Mosher and Thomas Williams, Instructors.

R. F. Edgar, Instructor in Civil Engineering, has been promoted to Assistant Professor; L. C. McCandliss from Associate Professor of Civil Engineering to Professor.

James A. Wasmund has been appointed Instructor in Electrical Engineering, and Henry C. Pavian, Instructor in Aeronautics.

F. H. Stiening, Instructor in Mechanical Engineering has been promoted to Assistant Professor.

E. Willis Whited, Assistant Director of Cooperative Work, has been made Director.

A new evening course in Safety Engineering is being offered this year and has aroused considerable interest among executives. The course is designed for those engaged in industrial safety work and those intending to follow Safety Engineering. It aims to place definitely the function of safety in management organization.

The School of Engineering is to have the distinction of conducting the first class in the Cathedral of Learning. The classes in freshman Drawing have become so crowded that the University officials are transferring all Drawing classes to the new Cathedral.

According to the latest figures, there is about 35 per cent. increase in enrollment in the various departments of the School of Engineering. In nearly every instance the number of freshmen enrolled is double that of last year's number The Aeronautical Engineering Department shows the greatest increase with a 60 per cent. higher enrollment.

Princeton University.—We are pleased to announce the appointment of Professor Lewis F. Moody as Professor of Hydraulic Engineering. Professor Moody has taught at the University of Pennsylvania and the Rensselaer Polytechnic Institute, at the latter institution he was Professor of Hydraulic Engineering and resigned in 1915 to devote his full time to practice as a consulting engineer of the I. P. Morris Corporation.

During the last year Associate Professor George E. Beggs has been promoted to a full professorship, and Instructor A. E. Sorenson has been appointed an Assistant Professor.

During the summer we have added a large number of electrical

instruments to our electrical laboratory, including a General Electric oscillograph, and the Mechanical Department has added condensing equipment for a number of engines.

The old Chemical Laboratory has been remodelled to care for the materials testing laboratory and for the laboratory of industrial chemistry.

Purdue University.—On October 2, 1930, 2801 undergraduates and about 100 graduate students were enrolled in engineering at Purdue University. The undergraduate students were distributed as follows:

Chemical Engineering	392
Civil Engineering	537
Electrical Engineering	764
Mechanical Engineering	1082
Industrial Education	26

The class distribution is as follows:

Freshmen	1060
Sophomores	794
Juniors	553
Seniors	389
Special Students	5
Total	2801

We do not have the exact data on graduate students but the number is somewhat more than 100.

Engineering Research.—Attached is a list of the live projects which are being carried on by the Purdue Engineering Experiment Station. Among these are included the following types of cooperative projects:

(*a*) The American Railway Association is cooperating with Purdue University in three projects which involve an expenditure of more than $200,000 a year.

(*b*) The Utilities Research Commission of Chicago is cooperating with Purdue University in studies of insulation, lightning protection and welding. These three projects have involved an expenditure for the year of about $39,000.

(*c*) The Indiana Limestone Company is continuing its cooperative relations which have existed for the past eight years. The appropriation by the Indiana Limestone Company has been $4,000 a year.

(*d*) The Indiana Gas Association is cooperating in studies of the utilization of manufactured gas and has appropriated for this purpose $10,000 a year with a definite assurance of five years.

(*e*) The Grigsby-Grunow Company is coöperating in studies of television and has appropriated during the past year, about $53,000.

In addition to the foregoing, we have a number of smaller contracts as well as some projects which are supported by Purdue University.

New Buildings.—(*a*) The late Thomas Duncan left the major portion of his estate to Purdue University for use in additions to the electrical engineering building and for equipment. The fourth unit of the electrical engineering building is now under construction and is the Duncan Memorial Laboratory of Electrical Measurements. Due to the fact that Mr. Duncan had been a pioneer in the manufacture of electrical meters, this particular portion of the electrical engineering building will be devoted to a museum, laboratory and other rooms devoted to exhibits, standardization and research on electric meters.

(*b*) The first wing of the new Mechanical Engineering Building is completed and is being used as a steam laboratory.

(*c*) New Chemical Engineering laboratories have been constructed during the past few months to be used for instruction in metallography and special investigations which have been carried on in cooperation with industry.

Special Lecturers.—The attached program announces a series of lectures by Professor A. Lipetz who is consulting engineer of the American Locomotive Works, and also a professor of Purdue University. Purdue University is attracting non-resident and visiting professors in a variety of subjects in order to keep the students and staff in contact with trends in industry.

New Curricula Changes.—The only major change in curricula pertains to the organization of a separate option in organic chemical engineering in the curriculum of Chemical Engineering. Also, graduate instruction in organic chemical engineering is being developed to parallel the graduate instruction in gas technology, metallurgy and other branches of Chemical Engineering.

New Appointments.—Chemical Engineering: R. Norris Shreve, Associate Professor; J. W. Campbell, Assistant Professor; and Robert Heyer, Instructor. Civil Engineering: S. C. Hollister, Professor of Structural Engineering; Phillip E. Soneson, Instructor; H. G. Kemmer, Assistant; J. E. Carson, Assistant. Electrical Engineering: Clyde R. Nichols, Instructor; J. H. Karr, Instructor. Mechanical Engineering: Arthur L. Freyman, Half-time assistant; Carl M. Giltner, Half-time assistant. Practical Mechanics: C. C. Sigerfoos, Assistant; J. N. Arnold, Instructor; Warren J. Luzadder, Instructor; Frank H. Smith, Instructor. Applied Mechanics: George A. Hawkins, Assistant.

Rensselaer Polytechnic Institute.—A department of architecture was inaugurated in September, 1929. At the beginning of the second year the number of students is sixty. The head of the department is Professor Ralph G. Gulley with Ralph E. Winslow as Associate Professor. Professor Gulley is a graduate of the University of Virginia, studying also at Ecole Americaine des Beaux-Arts and at Harvard University—from the last school obtaining a Master's degree in Architecture with a scholarship, two fellowships and several prizes. He has taught at the University of Virginia and at the Georgia School of Technology and has had four years' experience in architects' offices. Professor Winslow was graduated at the Massachusetts Institute of Technology where he obtained the Bachelor and Master's degree taking at the same time several prizes.

A building for the department of architecture is now being erected at a cost of $450,000. It will contain the latest equipment for buildings of its kind. An interesting feature will be the names of fifteen of the most celebrated American architects, now deceased, cut in stone tablets set in the faces of the building.

The Shop used for the instruction of students in the Mechanical and Electrical Engineering departments in pattern making, casting, forging and the use of lathes, planers, etc., is now being enlarged to a length of one hundred and forty-four feet.

The enrollment this year is the largest in the history of the school; more than 600 new students and a total of more than seventeen hundred students.

South Dakota State School of Mines.—Assistant Professor C. F. Bowles returns after a year of study in Chicago University, having received the Ph.D. in Mathematics. Mr. Graham Walton from Mass. Inst. of Technology becomes instructor in Civil Engineering. Mr. Geo. S. Cook, University of Kansas, becomes an instructor in Mathematics. Physical Education for Freshmen was inaugurated this semester following the completion of the new Gymnasium the past year.

On June 30 **Stevens Institute of Technology** opened for its first season the new college camp in engineering which is now a part of the required course in the Freshman year. The college purchased for the camp a tract of 350 acres near the Kittatinny Range in Northern New Jersey, approximately seventy miles from the main campus at Castle Point, Hoboken. The camp buildings erected on the wooded shores of a forty-acre lake which lies within the camp property, include a mess hall, 100 feet by 40 feet in dimension, a

drafting room and administration building of two stories, and sixteen dormitory cottages. The Camp Executive is Professor Samuel H. Lott of the college faculty, and the course of instruction, both in the field and in the drafting room was controlled by Professor David L. Snader of the Department of Civil Engineering whose staff consisted of three senior and fourteen junior instructors. Field and water sports were in charge of F. J. Misar of the college Department of Physical Education. Camp closed for this year on August 9.

With the present academic year Stevens Institute of Technology introduces for the first time in the sixty-year history of the college courses leading to a graduate degree. Since the inauguration of President Harvey N. Davis in the fall of 1928, a faculty committee has been investigating the place of graduate instruction in the Stevens curriculum and on the recommendation of this committee composed of Professors F. C. Stockwell, F. J. Pond, and R. F. Deimel, the trustees last spring authorized the establishment of graduate courses leading to the degree of Master of Science. The degree will be conferred upon the completion of eighteen units of study and the presentation of a thesis in the branch of science or engineering in which the student is majoring. Courses are given during the day only and the list of courses available for 1930–1931 include advanced courses in mathematics, dynamics, economics and business methods, chemistry, thermodynamics, flow of fluids, physics, gyro-compass theory and design, electrical engineering, structural engineering, mechanism and ballistics. The enrollment in graduate courses for the first year numbers sixteen, including four men appointed from the post graduate school of the United States Naval Academy: Lieutenants Stephen K. Hall, Harry Keeler, Radcliffe C. Wells, and Gerald U. Quinn. By arrangement with the Bell Telephone Laboratories, Dr. Walter A. Shewhart of the technical staff of those laboratories, is also conducting a course on "Statistical Theories and Methods Applicable to the Economic Control of Quality in Manufactured Products" which has been opened to professionally qualified persons outside of the graduate enrollment.

At the beginning of the current academic year Colonel Elliott H. Whitlock, until then Smoke Commissioner of the City of Cleveland, became Research Professor of Mechanical Engineering at Stevens Institute of Technology to devote his entire time to smoke abatement problems and a campaign against the smoke nuisance in the metropolitan area of New York and New Jersey. Colonel Whitlock is a graduate of Stevens of the Class of 1890 who of recent years has engaged in smoke reduction, especially in Cleveland where his program has had remarkable success. Stevens Institute

of Technology is a strategic point for anti-smoke work in the New York City area for its campus at Castle Point on the Hudson opposite Twelfth Street, New York, is approximately in the center of the district of industrial cities focusing on the port of New York. The college has offered the services of its "professor of smoke" to the various government and municipal authorities, and to the manufacturers and major users of fuel in the area. Colonel Whitlock's theme is that "where there is smoke there is waste" and that the manufacturer himself can be shown how to save money by eliminating smoke. The appointment of Colonel Whitlock at Stevens follows the organization a year or more ago of the New York-New Jersey Smoke Abatement Board under the auspices of the chambers of commerce of New York and New Jersey.

Syracuse University.—Mr. F. James McCanna, who received the degree of E.E. from Washington State University, has been appointed Instructor in Experimental Engineering at the College of Applied Science, Syracuse University, to replace Mr. J. Wardlaw Porteous, resigned. Mr. Porteous is at present Instructor at St. Joseph's College, University of Alberta, Edmonton, Alberta.

Several bulletins on Aerial Photo Surveying and Mapping have been published by Professor Earl Church of the College of Applied Science. The first Bulletin is entitled "Analytical Solution of the Problem of Topographic Mapping." The second one bears the title of "Topographic Mapping from Aerial Photographs by Measurements with the Sterocomparator." The third bulletin will soon be published. A limited number of these are still available for free distribution.

It is interesting to note that the registration of 371 for the College of Applied Science this fall is 14 higher than that for last year.

Covering a period of five years, **The University of Tennessee** is expending two and a half million dollars for new buildings. For the College of Engineering a new building has been erected this year and is now in use. It was planned as a central unit of a new plant. The building is primarily designed to house electrical, hydraulic and sanitary engineering. As the center of an engineering group, the new building houses the offices of the Dean of Engineering, contains the Engineering Library and the laboratories for engineering research. The building is of brick, concrete and steel, of the most approved fireproof construction. The cost is $250,000.

A. & M. College of Texas.—New members of the teaching staff are as follows: In Civil Engineering—C. S. Adams, a graduate of

this College; and L. A. Comp, formerly with the University of Oklahoma. In Drawing Department—Mr. L. A. Breland comes from Mississippi A. & M. College, while Mr. L. M. Haupt joins the Electrical Engineering Staff after several years' experience with manufacturing and operating companies. In Mechanical Engineering—Mr. W. E. Long joins the staff as Assistant Professor and Mr. W. I. Truettner as instructor.

Additional dormitory facilities for some 300 students have become available with the completion of Hart Hall and Ross Hall, formerly used for dormitory purposes, has been assigned to the Department of Architecture for overflow of classes and as a headquarters for the Texas Engineering Experiment Station.

On Monday, September 22, the new Cushing Memorial Library was opened for inspection. This modern building designed to accommodate a library of 300,000 volumes will add materially to the effectiveness of library work.

The leaders who conducted the groups of freshmen during "Freshman Week" this session are being given the general guidance for the men of their groups through the first semester. It is hoped by this method to maintain a more intimate personal contact with the large freshman class.

Tulane University.—The enrollment in this college is larger this year than ever before in its history. The Freshman Class shows an increase over last year of 30 per cent., while the increase in the college as a whole is about 14 per cent.

In the choice of course by the Freshmen, the largest number have selected the combined course in Mechanical-Electrical Engineering.

Chemical Engineering is second, with Civil Engineering and Architecture respectively third and fourth.

The Mechanical Engineering Laboratories are being rearranged in order to secure more space for the Hydraulic Department.

Professor W. B. Gregory, head of that department, has been appointed a member of the advisory committee of the National Hydraulic Laboratory.

Mr. Powell H. Humphries has been appointed Assistant Professor of Electrical Engineering to succeed the late Mr. Miner H. Vallas. Mr. Humphries was Instructor and Research Fellow in Electrical Engineering at Harvard University.

Mr. C. Boyd Norris of Austin, Texas, has been appointed Instructor in the same department. He is a graduate of the University of Texas.

University of Utah.—The Civil, Electrical and Mechanical Engineering Departments of the School of Mines and Engineering, University of Utah, have just moved into the first unit of the Engineering Building that has just been completed. This building cost $100,000 and is a fireproof reinforced concrete structure, four stories high with ramps between stories. It contains the Electrics Laboratory on the First Floor and offices, drafting rooms and class rooms on the other three floors.

Virginia Polytechnic Institute.—Registration in the School of Engineering on October 1, 1930, was 818 as compared with 719 for the entire session of 1929–1930.

A junior college of engineering has been established in the city of Richmond through a cooperative arrangement with the Virginia Mechanics Institute. This work is in charge of H. S. Grenoble, Associate Professor of Industrial Engineering. Thirty-one freshmen in engineering were registered on the opening days. This number is in addition to those given above who are in attendance at Blacksburg.

Staff additions: Mr. H. Vance White, V. P. I., '24, has been appointed instructor in metallurgy and metallography. Mr. Hamilton Parks has been appointed instructor in architectural engineering. Teaching fellows for the year 1930–1931 have been appointed as follows: W. D. Hurst, B.S., University of Manitoba, in Civil Engineering; W. D. Price, B.S., V. P. I., and C. E. Trent, B.S., V. P. I., in Experimental Engineering; D. C. Muller, B.S., V. P. I., in Power Engineering; A. I. Neihouse, B.S., V. P. I., and I. M. McNair, B.S., V. P. I., in Electrical Engineering; Research fellows in the Engineering Experiment Station are: L. S. Neilsen, B.S., Carnegie Tech., Plumbing and Heating; E. C. Meredith, B.S., V. P. I., Sanitary Engineering.

An honors curriculum in chemical engineering has been established in the junior and senior years. A grade average of B or better is required for admission to and for continuance in the honors group.

A new mechanical laboratory, of two-story factory construction, is now being erected. This will supply 20,000 square feet of additional floor space and will house the laboratories in hydraulics and in steam and gas engineering.

The materials laboratory has been increased to 5000 square feet by the addition of space released in McBryde Hall.

Increased space has also been made available for the laboratories in ceramic engineering and sanitary engineering.

A divisional library of engineering has been established in Pat-

ton Engineering Hall with Professor W. N. Cunningham in charge.

The curriculum in Geology formerly given in the Science College has been supplanted by a curriculum in Engineering Geology in the School of Engineering.

Four units of a new group of shops are being built at the **State College of Washington.** These will house auto mechanics, forge shop, machine shop and tractors.

At **Yale University** a new Sterling professorship of Engineering has been established and Professor Walter J. Wohlenberg, M.S., has been appointed as the first incumbent with the title of Sterling Professor of Mechanical Engineering.

Professor Herbert L. Seward, M.E., has been appointed the Robert Higgin Professor of Mechanical Engineering, succeeding to the chair left vacant by the recent death of Edwin H. Lockwood, M.E., Ph.D.

COOPERATIVE ENGINEERING EDUCATION

By F. E. AYER,

University of Akron

On January 25, 1930, our engineering faculty decided to investigate the present methods pursued in cooperative engineering schools in order to appraise our own work. The colleges were apportioned to the members of the faculty who studied the catalogs and corresponded with the Deans.

Mr. P. C. Smith and Mr. E. R. Wilson took the data thus gathered and tabulated them as shown in Table I. This report is in keeping with the expressed desire of Past President Rees of bringing up to date the investigation of engineering education made by the Society. Table I is a brief comparison of the status of cooperative engineering education as given by the very able report of the committee of the Polytechnic Institute of Brooklyn and published in the March, 1927, issue of the JOURNAL OF ENGINEERING EDUCATION, which applies to 1925, and the present status of such education in 1930.

The total enrollment of cooperative engineering students in 1925 was 5550 students enrolled in sixteen schools. In 1930 we find nineteen engineering schools using the cooperative method with a total enrollment of 9550 or an increase of 70.8 per cent. in students and 18.6 per cent. in number of schools. The 5550 cooperative engineering students in 1925 was 10 per cent. of the total number of engineering students enrolled in this country. In 1930, the 9550 cooperative students is 13.5 per cent. of the total number of engineering students enrolled or an increase of 3.5 per cent.

Comparing the amount of school time in weeks as given by the different institutions we find that in 1925 there were two schools giving less than a total of one hundred weeks; one giving eighty-four and another ninety, with an average for the sixteen schools of 118.5 weeks. In 1930 there is only one school giving less than one hundred weeks, and that one gives ninety-six weeks of school instruction. The average for the nineteen colleges operating in 1930 is 120.7 weeks.

Referring to the length of alternating periods there is now a decided trend toward a longer period of alternation. In 1925 there were two schools with a two-week period and two with a three-week

TABLE I

College		Yrs. Required	Coöp. Work Begins	Length of Alternating Periods	Total Coöp. Time	Total School Time Wks.	Ratio Coöp. School Wks.	Total Coöp. Enrollm.
U. of Akron	'30 '25	5	2d sem. 1st yr.	9 wks. 3 wks. or 6 wks.	113 123	115 106	.98	245 146
U. of Cincinnati	'30 '25	5	1st yr.	4 wks.	123	107	1.15	1,609 1,144
Detroit Institute of Technology (Y.M.C.A.)	'30 '25	5	2d mo.	4 wks. 2 wks.	130 139	100 90	1.30	198 88
U. of Detroit	'30 '25	5	1st yr.	4 wks. 2 wks.	115 124	115 107	1.00	1,270 400
Drexel Institute	'30 '25	5	2d yr.	12 wks.	84	132	.64	851 498
* Evansville College	'30 '25	5	9th mo.	3 wks. or 6 wks.	110	119	1.00	104 95
Fenn College Cleveland	'30 '25	5	1st yr.	5 wks.	124	112	1.10	280
Georgia School of Technology	'30 '25	5	5th wk.	4 wks.	130 124	115 111	1.13	608 330
General Motors Institute of Technology	'30 '25	4	1st yr.	4 wks.	104	96	1.08	619
U. of Louisville	'30 '25	4	2d yr.	12 wks.	52	132	.40	† 58 58
Marquette U.	'30 '25	5	3d yr.	4 wks.	78 72	134 133	.58	509 447
Massachusetts Institute of Technology	'30 '25	5	3d yr.	18 wks.	79	136	.58	233 274
New York U.	'30 '25	5	3d yr.	16 wks.	65	144	.45	100 111
Newark Technology	'30 '25	4	3d yr.	4 wks.	78 69	116 116	.67	405 175
U. of North Carolina	'30 '25	4	3d yr.	13 wks. 8 wks.	26 26	142 137	.18	255 188
Northeastern	'30 '25	5	2d yr.	5 wks.	‡ 98	110	.89	1,318 1,032
U. of Pittsburgh	'30 '25	4	2d yr.	18 wks.	36 52	132 131	.273	446 469
Southern Methodist	'30 '25	5	5th wk.	4 wks.	130 124	115 111	1.13	312 95
U. of Tennessee	'30	5	2d yr.	11 wks.	88	121	.72	130

period. In 1930 we find the minimum length of period to be four weeks with the exception of Evansville College which contemplates a change this year. There seems also to be a trend toward keeping the student in school for at least one semester before sending him out in cooperative employment.

We also asked each Dean what, in his opinion, are the chief advantages of the cooperative method in engineering education. These opinions are interesting and cover a wide range, but there is nothing in them which would add particularly to the expressions given in the report of the S. P. E. E. committee. And after all, they are only opinions and as such are of no particular value to anyone. The cooperative method is one which must be adapted to the individual institution and its industrial environment. Therefore, many of the much discussed questions, such as length of alternating periods, type of industrial experience, relative amount of time in school and industry, are all questions which must be answered by each institution.

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* May 28, 1930.

" . . . .

"1. It is definitely decided that we will keep students in school one year, and it is more than likely that the following year we will change to two years of full time work, followed by three years of cooperative work. I think as this publication is going forward it would be well to make a note that we favor and are gradually adopting the two-year full time basis before cooperative employment.

"2. As regards shift duration, would state that although we operate on three weeks, at present it is quite likely that that shift will be increased to probably half a semester within the next year, that is nine weeks, alternation, half a semester. This is not definitely decidedly as the other matters above are.

" . . . .

"L. B. HOYT, *Acting Director,*
Department of Engineering."

† No enrollment reported, 1925 enrollment assumed.

‡ 1 cooperative year	20	124
3 cooperative years	72	84

T-SQUARE PAGE

RESEARCH IN DESCRIPTIVE GEOMETRY AND ENGINEERING DRAWING

The publication of Professor Clair V. Mann's studies on the objective type of test as applied to engineering drawing and descriptive geometry marks a new high point in the development of research in technical graphics. At the Chapel Hill meeting of the Engineering Drawing Division in 1928 and at the Summer School for teachers of engineering drawing in 1930 Doctor Mann presented advance reports on his researches.

Mr. R. J. Grant of the Oshkosh Teachers College has developed a plan for training in visualization by the use of plastic clay, and has also developed a testing program to measure the degree of mastery attained by the student, as well as providing a remedial testing program for the instructor.

Briefly, Mr. Grant believes that by requiring the student to construct from plastic clay the object represented he will not only learn how to interpret drawings, how to "see" and visualize the actual object represented, but will also provide the instructor with a diagnostic check on his power to visualize.

According to Mr. Grant, plastic clay permits the student to visualize a hundred or more problems in a semester course. The clay works easily and mistakes are easily corrected. For modelling tools Mr. Grant recommends hack saw blades, cylindrical and square brass tubing for punching out holes, and kitchen knives.

The use of motion pictures in teaching descriptive geometry has been introduced by J. M. Miller of Rice Institute. At the Summer School for Drawing Teachers, Mr. Miller showed several films of propositions which he had "animated" and used successfully in teaching. The advantage to the student lies in the creation of a picture which appears to be three dimensional and which is built up point by point, and line by line in step with the explanation.

Two instructors in the Newton, Iowa, public schools have used film slides successfully in teaching drawing. A description of their method may be found in the January (1930) issue of *Industrial Education Magazine*.

Sectioning students in engineering drawing and in descriptive geometry is being studied by the Departments of Engineering Drawing at the University of Illinois and the University of Michigan. It is hoped that a condensed report of the findings of these two institutions may be published later.

THE PROJECT METHOD IN RESEARCH *

By JOHN MILLS

Bell Telephone Laboratories

In 1909 the chief engineer of the American Telephone and Telegraph Company made an extended visit to the territory of the Pacific Telephone and Telegraph Company. He found himself, as he knew he would, out of telephonic communication with his New York office. The experience emphasized anew in his mind the desirability of a more universal system of communication than was then possible, for at that time the limit of commercial service was approximately the distance between New York and Chicago.

When General J. J. Carty, who was then chief engineer, returned to New York he started the project of New York–San Francisco telephone service. In a memorandum, to the vice president to whom he then reported, he outlined the program. The first step, of extending service from New York to Denver, was immediately practicable, involving no considerable amount of research but requiring between Chicago and Denver the largest conductors then employed for telephony, loaded with suitable "Pupin" coils.

New York to Denver, however, was the practical limit without the development of a telephone repeater and of methods for adapting the repeater to the line, or vice versa, in such manner as to permit the tandem operation of repeaters at successive points along a circuit extending across the country. An electromagnetic, that is mechanical, repeater was available at the time, but in its then design and in the existing state of knowledge as to adapting lines to repeaters it could not be considered as a suitable means for transcontinental telephony.

General Carty's memorandum, therefore, which asked for more men and dollars, centered attention on the project of the development, by further research, of a telephone repeater suitable to operation on long loaded-lines. His memorandum, however, went further and pointed out that the problem of long-distance radio-telephony might expect solution as a result of the development of a satisfactory telephone repeater.

A small group of scientists was selected and research initiated. That their researches under the general guidance of Dr. F. B.

* Presented at the 38th annual meeting of the S. P. E. E., Montreal, Canada, June 26–28, 1930.

Jewett and Mr. E. H. Colpitts were successful, and that the engineering and operating problems were solved under the leadership of Mr. Bancroft Gherardi of the Telephone Company, and telephone communication between New York and San Francisco established in 1914 are matters of history, with the details of the physical developments recorded years ago in the technical literature.

The group of scientists thus assembled became the nucleus of the present research department of Bell Telephone Laboratories; and Dr. H. D. Arnold, the member of the group whose developments were most important, its present director.

A satisfactory repeater element, in the form of a high-vacuum thermionic tube evolving from the DeForest audion under Dr. Arnold's efforts, had no sooner appeared than other projects were under way. Among these the most spectacular was that of accomplishing a definite and pronounced extension in range of radio-telephony by transmission from Arlington, D. C., to Paris, France. This program, which met success late in 1915 laid the basis for the present day commercial service which the American Telephone and Telegraph Company offers between the United States and Europe.

Another project growing out of the repeater development was an extensive and still continuing series of investigations into speech and hearing in which there participated a large number of scientists, notably, Dr. Harvey Fletcher. To that project must be credited much of the present high quality and naturalness of telephone transmission and of radio broadcasting, as well as such later developments as improved sound records and systems for sound pictures.

Numerous other projects arose or evolved out of the original, for example, the multiplexing of transmission lines for the simultaneous transmission of several telephone messages by so-called carrier-current methods. In its earliest form this project met success in the simultaneous transmission of two separate telephone messages over a pair of wires connecting two rooms in Bell Telephone Laboratories or, as it was then known, the Engineering Department of the Western Electric Company. That work got underway before the transatlantic radio-telephony and, in fact, contained some of the experiments basic to that later exploit. It reached a stage of field trial in the days before the War; and served effectively in the later wartime congestion of telephone traffic.

These are not by any means the first instances of research projects; but they are the earliest and most important which it has been my fortune to observe. And because their results are so widely known and socially important they may serve as an introduction to what I have called in the title of this paper "the project method" in research. The words "project method" are obviously

taken over from primary school pedagogy with some, but not all, of those connotations. Before I attempt to develop their significance in connection with research let me describe one or two incidents which will serve as an illustration.

The director of a musical school of considerable prominence and success came into our laboratories some time ago to get information as to the equipment of a laboratory for studying the problems of acoustics which related to instruction in instrumental music and voice technique. Considering that a very full order, I asked him what particular experiment he had in mind? what particular information he was in search of? I found out he had no particular project in mind.

Somewhat similarly we received an inquiry from a physics professor in a university where they were building a new laboratory and wished to equip a portion of it for acoustical research. Again I took the liberty of trying to find out what particular experiment was in mind, with the idea of gathering from the scientists in the Laboratories the latest information as to equipment for attacking that particular problem. But there was no particular problem in mind.

These two instances are cited without reflection on the inquirers to illustrate the other extreme in research—the broad frontal attack on the unknown. Much may be said for research outlined on the plan of broadening knowledge in a certain general field. There is a certain Baconian satisfaction in looking at a whole field of human knowledge and in classifying and trying to extend it. This is probably the justifiable attitude of "pure" research and the project method may be characterized, or stigmatized, as peculiarly fitting to industrial research with its necessity of justification for its expenditures and its hope of ultimate financial reward. Projects, on the other hand, are not always to be commended; for example, there was the inquiry which we received for equipment to permit a "study of the relation between metabolism and the carrying power of the voice."

The adoption of a project permits a unified and coordinated research program; it adds direction, prevents scattering of effort and rolls up ideas, methods, techniques and results with a cumulative effect like that of compound interest. The research grows and branches like a tree, with new shoots and budding problems springing from the last season's growth. Its roots meanwhile reach farther and farther back into the fundamentals of the sciences upon which it depends, entering new ground, tapping new veins of knowledge and venturing into a dark unknown.

It was out of the project method that came the important physical discovery by Dr. C. J. Davisson that a stream of electrons

is diffracted by a crystal as if they were a beam of waves. A pure science discovery, but in effect a result of the interest of Bell Telephone Laboratories in the project of obtaining more cheaply the electrons which are so useful in vacuum tube devices, and hence, pushing back still further into the unknown, in an interest in knowing more about electrons.

There is, of course, always the danger that a project may be too narrow, but I believe that the inconvenience of that method is rather that it turns out to require too large a variety of training and experience for its completion. Few projects are limited to a single field of science. Sooner or later the workers must cross the arbitrary boundaries between chemistry and physics; between electrical engineering and mechanical engineering; between physics and biology or psychology, and sooner or later there may enter an economic interest or motive. The chemist interested in wood preservation for poles and crossarms becomes a biologist experimenting with fungus growths; the telephone engineer approaches the phonetician, and the radio engineer may turn meteorologist and a student of the ionized upper layers of the atmosphere.

Motivation is usually keener when effort can be centered on some definite project. The growth of research is then a more or less natural evolution, guided somewhat perhaps by pinching off inopportune buds or failing to give financial nourishment to shoots which do not promise rapid and firm growth.

The very fact that projects do so grow and enlarge calls for some systematization and coordination. There is a call also for common interest and cooperation between specialists in apparently widely separated sections of science. A project permits to individuals a variety of selections and assignments to different phases of the main problem in accordance not only with scientific training and experiences, but with temperamental interests and personal peculiarities as well. The experimentalist and the theorist, the designer, the operating technician, and the more routine worker, each finds a part in a well coordinated attack on a sizeable project.

Perhaps because the project method is so peculiarly the method of engineering industry it should appeal to technical schools. In most instances they serve a certain community of the public, state bounded or otherwise, not only in the education of its members but even more importantly in the development, storing and passing on of scientific knowledge of value to that community. A project comes to my mind which happens to have been undertaken in the Laboratories, from which I must draw most of my illustrations, but might equally well have been chosen by any American technical school, particularly those in the South. I mean the investigation into the factors underlying textile insulation and the resulting dis-

covery that proper washing of cotton would make it an insulator superior to ordinary silk. The apparatus required for that investigation was relatively simple, the ingenuity considerable, and the ultimate financial savings promise to be very large.

That the project method has proved serviceable in industrial research will be rather generally admitted. The question of how far it should be applied in academic activities however, is one to which the answer is not so obvious. About all that can be justly urged at present, it seems to me, is the need, because of its industrial success, for consideration of the method by educators.

It is, of course, only one method of systematizing research. Whether or not research should be systematized, or rather how far such efforts can go without endangering the results, is also a matter for deliberation and judgment. In your consideration of that question I wish you could all read a short paper on the subject by Dr. H. D. Arnold, as presented before the Sigma Xi chapter at Columbia some time ago. With that in mind I have had the paper reprinted and copies may be obtained by addressing the Bureau of Publication of Bell Telephone Laboratories.

The project method, as I am using the words, may now be summarized as the method of systematizing research in which a rather definite objective is established and the research activities of a group of workers coordinated towards its accomplishment. The objective may be quite specific but it should not be too narrow since, according to the present concept, it must enlist a considerable group of workers and a wide variety of interests. Recognizing our American peculiarities of temperament, I should be inclined to say also that the objective should have some probability of economic and social value as well as of scientific importance. Such probability will, I believe, prove stimulating rather than embarrassing to those engaged on the more scientific phases of the project; and at the same time it attracts the larger groups whose interests lie in practical application and utilization and in human and economic relationships.

When, however, one considers projects on large scientific, economic and social scales one recognizes immediately that there may be difficulties in the organization, for the attack, of the loosely related and largely autonomous departments of a university. The answer may lie in allowing the project to evolve both in its technical aspects or direction and in the organization of its workers. If it has been well chosen—if, in other words, it has value and interest, it may be counted upon to attract workers to its various phases, particularly as it gets underway and success seems probable.

Industry has indicated the possibility of such evolutionary development. Although, in our laboratory work for example, it would have been possible in many instances for executives to have

coordinated departments likely to be concerned long in advance of the need, it has, I believe, usually been found that the best method was to allow the proposed project to evolve. A single department usually initiated a project under, of course, executive approval. Then as need for advice and investigations by other groups of scientists or engineers arose those departments were included and money was assigned proportionately for their activities.

Although there are, of course, vital differences between industries and universities in organization, in point of view, financial arrangements and incentives, each may learn from the other as to the attack on research. In fact industry has so learned and profitted, and frequently admits publicly its debt to the universities of the world. What part of the methods of each may be transferred or adopted is, of course, open to question, to analysis, and very probably to a pragmatic solution by trial and error. All that is attempted in this paper, and all that is hoped for, is again to direct the attention of educators, interested in research, to the project method.

GETTING STUDENTS TO LEARN *

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Some years ago a flippant student at one of our large universities published a book called "Pedaguese." As its title implied, the book was concerned with the language which professors of pedagogy are reputed to use in dealing with their subject. The book pretended to be a "trot." Its left-hand pages contained long and involved excerpts from the writings of prominent teachers of education; its right-hand pages offered alleged translations of the excerpts into straight-forward English. The left-hand pages were almost uniformly packed with solid print. The right-hand pages, in striking contrast, were nearly always brief: they set forth at most two or three somewhat obvious ideas in simple language. The book reached its climax in a number of masterly left-hand pages—pages black with erudite "pedaguese"—faced by right-hand pages which were entirely blank.

People who are not themselves intimately concerned with the professional study of education seem in many cases to have formed their opinions of education as a subject of study through the reading of some such book as this. Some have apparently read chiefly from the right-hand pages—the purported "translations" of educational dicta—and have concluded that the study of education has little or nothing to offer for the improvement of teaching. Such people are likely to hold that mastery of subject matter is the only essential prerequisite to good teaching, though a modicum of common sense and an agreeable personality are desirable supplementary qualities. There is, I think, more than a little evidence that they are mistaken. Others have apparently read exclusively from the left-hand pages, and have concluded from them that education is fast on the way to become a science of magic. Persons who have faith in many of the current advertisements of correspondence courses—in the virtue of copyrighted schemes for training the will or in the possibility of learning to speak French like a native in six easy lessons—must rest their faith on some such belief in educational magic. There is abundant reason to believe that they too are mistaken.

* Summary of a discussion presented at the Civil Engineering Session of the Summer School for Engineering Teachers, Yale University, July 1, 1930.

Whether the study of education can defend as real contributions all the educational findings that are couched in "pedaguese," or whether these findings are, in fact, only an abstruse reiteration of common-sense, I do not pretend to judge. So far as this present discussion and those which are to follow it are concerned, I can promise to set forth no new and magical practices in teaching, and no shortcuts to perfection. The job of learning presents, I suspect, about as hard a row to hoe as it ever did, and the job of teaching is only somewhat less difficult than it used to be. Teaching is, in a sense, somewhat less difficult, because the study of education, while providing no shortcuts, has shown us that certain "common-sense" practices are superior to other practices also supposed to be based on common-sense. It is with a number of common-sense practices as we now understand them that I propose to deal—practices which are already familiar in a measure to most teachers, but upon which the study of education has thrown interesting light.

From the day he starts teaching to the day he retires, every teacher finds himself confronted with the problem of getting his students to learn. He may seek to avoid the problem by denying that it exists—by maintaining stoutly, as is the habit of many college and university teachers, that his duty as a teacher requires him merely to set before his students the things they ought to learn, and that the responsibility for learning those things rests with the students themselves. But even though a teacher denies the problem he does not cease to be interested in evidences of whether his students *do* learn—in their marks on his examinations, their records in courses which follow his, even in the size of his class-enrollments from year to year. And when the evidence that he has not got his students to learn becomes sufficiently impressive, even the teacher who disclaims his responsibility in the matter is likely to search for ways to make his teaching more effective. What are the best ways of getting students to learn when the students themselves avoid responsibility for learning?

There is one easy and obvious answer to this question—so easy (apparently) and so obvious that it is likely to be the first resort of the teacher in distress. There occurs an excellent illustration of this answer in a chapter of Ian Hay's "The Lighter Side of School Life," in a description of a class in an English public school. Though Ian Hay is writing about secondary-school pupils instead of college or university students, and about a course in Greek and Latin instead of a course in engineering, he describes a method of teaching which is likely to be thoroughly intelligible to any teacher of any subject, and which is eminently worth considering.

"Mr. Dumaresq was reputed to be the hardest slave-driver in Eaglescliffe. His eyes were cold and china blue, and his voice was like the

neighing of a war-horse. He disapproved of the system of locked form-rooms—it wasted at least forty seconds, he said, getting the boys in—so he made his head boy keep the key and open the door the moment the clock struck.

"Consequently, when upon this particular morning Mr. Dumaresq stormed into his room, every boy was sitting at his desk.

"'Greek prose scraps!' he roared, while still ten yards from the door.

"Instantly each boy seized a sheet of School paper, and having torn it into four pieces selected one of the pieces and waited, pen in hand.

"'*If you do this,*' announced Mr. Dumaresq truculently, as he swung into the doorway, '*you will be wise.*'

"Every boy began to scribble madly.

"'*If you do not do this,*' continued Mr. Dumaresq, '*you will not be wise. If you were to do this you would be wise. If you were not to do this you would not be wise. If you had done this you would have been wise. If you had not done this you would not have been wise.* Collect!'

"The head boy sprang to his feet, and feverishly dragging the scraps from under the hands of his panting colleagues, laid them on the master's desk. Like lightning Mr. Dumaresq looked them over.

"'Seven of you still ignorant of the construction of the simplest conditional sentence!' he bellowed. 'Come in this afternoon!'

"He tossed the papers back to the head boy. Seven of them bore blue crosses, indicating an error. There may have been more than one mistake in the paper, but one was always enough for Mr. Dumaresq.

"'Now sit close!' he commanded.

"'Sitting close' meant leaving comparatively comfortable and secluded desks, and crowding in a congested mass around the blackboard, in such wise that no eye could rove or mouth gape without instant detection.

"'*Viva voce* Latin Elegiacs!' announced Mr. Dumaresq, with enormous enthusiasm. He declaimed the opening couplet of an English lyric. 'Now throw that into Latin form. Adamson, I'm speaking to YOU! Don't sit mooning there, gaper. Think! Think!

Come, lasses and lads, get leave of your dads—Come on, man, come on!
—And away to the maypole, hey!

Say something! Wake up! How are you going to get over 'maypole'? No maypoles in Rome. Tell him, somebody! "Saturnalia"—not bad. (Crabtree, stand up on the bench, and look at me, not your boots.) Why won't "Saturnalia" do? Will it scan? *Think!* Come along, come *along!*'

"In this fashion he hounded his dazed pupils through couplet after couplet, until the task was finished. Then, dashing at the blackboard, he obliterated the result of an hour's labour with a sweep of the duster.

"'Now go to your desks and write out a fair copy,' he roared savagely.

"So effective were Mr. Dumaresq's methods of inculcation that eighteen out of his thirty boys succeeded in producing flawless fair copies. The residue were ferociously bidden to an 'extra' after dinner. Mr. Dumaresq's 'extras' were famous. He held at least one every day, not infrequently for the whole form. He possessed the one priceless attribute

of the teacher: he never spared himself. Other masters would set impositions or give a boy the lesson to write out: Dumaresq, denying himself cricket or squash, would come into his form-room and wrestle with perspiring defaulters all during a hot afternoon until the task was well and truly done. Boys learned more from him in one term than from any other master in a year; but their days were but labour and sorrow." *

Is not this the answer to the problem of getting students to learn? Let the teacher be eternally vigilant in seeing that his students occupy themselves only with their classwork in his class periods; let him set him standards high; let him insist inexorably, under pain of penalties which really hurt, that those standards be lived up to by every one of his students—let him, in other words, simply *make* his students work—and may he not confidently expect that boys will learn "more from him in one term than from any other master in a year"? And if the days of those boys happen to be "but labour and sorrow," will not the boys themselves at length value their learning more highly on that very account?

Probably the reply to these questions will be "yes," if one does not look too closely at the results of compulsion as a method of getting students to learn. Most of us who have gone successfully through high school and college can recall at least one Mr. Dumaresq in our own experience—a teacher whose courses we are proud to have "passed," and from whom we confidently believe that we have learned much more than from our other teachers, though the process of learning may have been far from agreeable. The great majority of our teachers are likely, as a matter of fact, to have relied largely upon some such method of compulsion, so that instead of being unique a Dumaresq stands out for us merely because he has compelled more urgently and more conscientiously than the rest. It is only when one seeks to discover what sort of learning the compulsion has brought that one becomes fully aware of the defects of this method.

It happened that a few years ago I served for a time on the Board of Freshman Advisers of Harvard College. The members of this board are responsible, among other things, for guiding students' choices of courses during their first year in the College. In the case of most entering students the choice of Freshman courses is to some extent determined in advance by certain Rules for Distribution of Courses adopted by the Faculty. These rules provide that during his college career each student must elect at least one full course from each of four specified fields; and since students were urged to take as many of these courses as possible during their first year, and since the appropriate courses in three of the four

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fields were usually obvious in the case of any single student, the problem of advising students in this matter was never highly involved. But certain difficulties appeared in connection with the choice of courses in science, which was one of the required fields. Physics, chemistry, biology, botany, zoölogy, geology, and meteorology, all were open to Freshmen, and a laboratory course in any one of these subjects would satisfy the requirement of a course in science. It seemed to me reasonable, at first, to suppose that a student who had had an introductory course in science as a part of his secondary-school work would be interested in electing a college course in science in the same field. Hence to students whose entrance records showed satisfactory work in high-school physics I would suggest Physics C as an elective; to those who had passed in high-school chemistry I would propose second-year college chemistry. But it soon became apparent that a continuation of their high-school work was the last thing that most of these boys wanted. Those who had presented physics for entrance evinced a surprising ambition to inquire into the complexities of college chemistry; those who had studied chemistry in high school wanted to take up physics in college; and the few who had already studied both physics and chemistry were all athirst, so they claimed, for an elementary knowledge of geology or meteorology or a like science not taught in high schools. Most of the boys—those who had barely passed for admission as well as those who had gained honor grades in their entrance examinations—professed themselves much interested in the science courses they had studied in high school and anxious to change their fields of study only because of what they had heard about specific college courses. But occasionally some statement came out which seemed nearer the truth, as, for example, in the case of the boy who said bluntly: "I don't know what meteorology and zoölogy and that sort of truck is all about, but if I've got to take one of them I suppose I've got to. I'll sign up for any one of them you say. But I had physics and chemistry in high school, and believe me! you couldn't get me to take any more of that stuff on a bet!"

An instance of this sort proves nothing. It may, however, give point to a serious doubt as to the effectiveness of a method of teaching which consists for the most part merely in making students work. That the present system of entrance requirements for the Eastern colleges does lead teachers to rely largly upon such a method, few who are acquainted with existing conditions will deny. Here were boys who were products of the method. They were boys, too, who had learned more in one term than had many of their classmates in a year—else they could never have survived the competition that admitted them as Freshmen to Harvard College. Yet

in spite of their success, their most earnest ambition was to have nothing further to do with the things they had learned, and to keep as far away as they could from courses which would give them more of those things.

It would be possible to multiply illustrations of this sort almost indefinitely, in the case of nearly every phase of our high-school and college curricula. Teaching through compulsion—merely by "making students work"—may produce learning of the sort that enables students to pass satisfactory examinations. It may even produce learning which a student retains and finds valuable, providing the student is placed subsequently in situations in which he is forced to have and use that learning or to fail. But teaching through compulsion is likely always to be working against itself, even when it seems superficially to be most effective. It works against itself, in the first place, by creating the strongest possible distaste for the things that are learned—a distaste which impels any but the most exceptional student to have done with those things as soon as may be. It works against itself, also, by creating distaste for the process of learning, so that only by more and more compulsion can its victims be got to learn. It goes far, in a word, toward insuring the solution of the problem of getting students to learn, not so much by getting the students to learn as by getting speedily rid of the students who do not care to learn.

Compulsion alone, then, easy and obvious though it frequently seems as an answer to the problem, is likely to be of no very permanent value. Clearly there must be some other way out if the teacher is to be successful not merely in getting his students to learn, but in getting them to use what they learn and to go on learning more. What that way out may be will be suggested, perhaps, by a brief examination of certain fundamental conditions which always exist when a student is learning under the guidance of a teacher. There are at least three such conditions which the teacher must recognize if his teaching is to be thoroughly effective.

The first of these is perhaps almost too obvious to need statement: *the student's coöperation in his own learning is essential.* The student cannot be expected to learn except as he is willing to go through at least the motions of learning—except, that is to say, as he is to some extent interested in the learning in question or in what he expects to derive from it.

The second condition is less obvious. It involves, indeed, a flat contradiction of the position of those teachers referred to earlier, who maintain that responsibility for whatever learning students may do rests wholly with the students themselves. *The teacher is primarily responsible for securing the student's coöperation in learning.* That teacher is not doing full justice to his task, in other

words, who does not seek to make his students willing to go through the motions of learning—who does not attempt to awaken the active interest of the students either in the learning itself or in the results of learning.

Consider briefly the situation with which any teacher is confronted when he meets any class of students. He could classify his students, if he would, into three groups according to their interest in the subject matter with which he is dealing.* One group would consist of students already actively interested in the subject, as a result of their acquaintance with it either in the course in question or in previous courses. A second group would consist of students who were neutral toward the subject—who held no prejudice against it, but who had not yet found in it anything to enlist their active interest. The third group would contain students who were positively hostile (of whom there may be some in almost any course) —students who had entered the course under some sort of compulsion, and who had learned from previous experience, either in that course or in similar courses, to expect nothing but boredom or worse from it. With these three groups of students the teacher is faced, in the expectation that he will develop to the full in each student, through his teaching, such potential abilities as each one may have in the subject matter with which the course deals.

Assume, now, that the teacher undertakes no responsibility for the attitudes of his students, but simply lays his subject before them. If no sort of compulsion is present, the achievement of each student is likely to be directly in proportion to his interest in the course. He will learn just so much as his prejudice leads him to find agreeable, and no more; and the dull but interested student will probably far exceed in accomplishment the potentially capable but hostile one. For the results the teacher in question will truly be not responsible: it will be some previous teacher, or some casual experience on the part of individual students, which will have determined the interests of his students and will thus have determined the success of his teaching. If, moreover, the teacher is completely successful in avoiding any appeal to the interest of his students, he runs serious risk of strengthening whatever disinclination to learn may already have been present—of making interested students either neutral or hostile, of driving formerly neutral students into active hostility, and of confirming already hostile students in their low opinion of the whole business.

Were the potential capacity of a student in a given subject fairly measured by his interest in that subject, these effects might

* This method of classifying students according to their interests was brought to my attention by my colleague, Professor Bancroft Beatley, to whom I am indebted for much in the present instance.

not be so unfortunate. Together with the result of a little compulsion in learning, judiciously applied according to the methods of Mr. Dumaresq, the deadness of the teaching would doubtless speedily bring about the elimination of the least interested and hence supposedly the least capable students, leaving the teacher free to cultivate to the utmost the presumably superior abilities of those who were interested in spite of him. But it is not true that potential ability and present interest in learning necessarily go hand in hand. Lack of interest does not of itself mean lack of capacity, and there is abundant evidence that neutral or even hostile students, if once their interest in a subject can be aroused, have capacity to do well in it. If the teacher is under any obligation whatever to see that his students profit from his teaching according to their potential capacities, he cannot be indifferent to their interest in learning. He must, indeed, consider the development of his students' active interest in the subject matter with which he deals one of his primary concerns as a teacher.

Thus for the second of the essential conditions which the teacher must recognize: the teacher himself is primarily responsible for securing the student's coöperation in learning. The third is closely related to the second: *the student's coöperation in learning is most effective when the teacher's purpose and the student's purpose are identical*—or, in different words, when the student wants to do what the teacher wants him to do because the student is thoroughly interested in the undertaking in question. What this third condition means in terms of definite teaching practice may be illustrated, negatively at least, by reference once more to Ian Hay's account of Mr. Dumaresq's class.

Mr. Dumaresq was deeply concerned that every boy in his class should give constant attention, and complete attention, to the business of the classroom. That business, he recognized, was not the only thing to which a normal boy might attend: temptations to look out of the window, to talk to other boys, to seek relief in disturbances of one sort or another, to take advantage of any sort of diversion, were always present. He sought, therefore, to build a wall around each boy which would shut out the possibility of every sort of activity but one—the activity involved in studying Greek and Latin. His wall consisted in part in providing something for every boy to do from the very moment he entered the classroom. "He made the head boy keep the key and open the door the moment the clock struck. . . . 'Greek prose scraps!' he roared, while still ten yards from the door." The wall was fortified by an arrangement for "sitting close," which "meant leaving comparatively comfortable and secluded desks, and crowding in a congested mass around the blackboard, in such wise that no eye could rove or

mouth gape without instant detection.'' Its final reinforcement was the energy and determination of the teacher—his hounding of the pupils through the whole class-period, his provision for "extras," his willingness to "wrestle with perspiring defaulters . . . until the task was well and truly done." Clearly Dumaresq had here as nearly hole-proof a construction of its sort as one could well expect to find.

And yet it was by no means holeproof. Adamson sat and mooned. Crabtree looked at his boots. The class as a whole demanded constant prodding, driving, urging. And the explanation is not hard to find. The wall which Dumaresq erected did indeed make it difficult for his students to give attention to anything except the work he set before them, but it made it by no means impossible for them to attend to other things, and it made those other things certainly no less attractive by comparison. Moreover, it changed the students' intentions not at all. Their intentions were readily apparent: to do their work if they had to, in order to avoid the unpleasantness which would follow their not doing it, but to do not one whit more than they had to in order to escape that unpleasantness. The question that was uppermost in the mind of every boy was not how to do his work to the best of his ability, but how to avoid doing as much of the work as he could possibly get out of.

Dumaresq, to be sure, adopted purely negative means for keeping his students' attention—means paralleled in our colleges and universities by the rules against "cutting," the probation lists, the penalties for failure in examinations, the interviews with the dean, the exercise of suspension and expulsion, which occupy so large a place both in faculty minutes and in collegiate tradition. Dumaresq (and the colleges) might perhaps have hoped for greater success through a more positive sort of urging—through rewards for high scholarship, prizes for excellence in competition, diplomas or certificates formally endorsed. But even such spurs as these offer only a half-way promise. They are likely to be effective with a few students only; and even for those to whom they do appeal they result again in the creation of a divided interest. The student who is working for a prize, like the student who is exerting himself to keep off probation, finds the standard of his accomplishment dictated for him by the immediate purpose that he has in view. He will devote to his studying just so much interest and attention as he conceives necessary to "get by" in terms of that purpose; and with the purpose once achieved, the learning that has made its achievement possible is of no more importance and will in all probability be quickly forgotten. Nor is there any condemnation here implied for the student in question. He would be an unintelligent

student indeed who, electing to play the game, failed to observe the rules.

If compulsion alone will not work, and if compulsion and rewards together promise only half-way success, what can the teacher do? There would seem to be only one thing: to make his teaching itself of so much interest to his students that for the time being, at least, it will outweigh immediate sources of distraction. The teacher who can do this need build no wall to prevent the wandering of his students' attention: the students will of themselves attend to the things they are interested in learning. The teacher who can do this need, moreover, have little fear that his teaching will be dismissed from his students' thoughts as soon as his course is over: he may expect, indeed, that they will hold as fast as the limitations of the human mind will let them to what they have learned, and try to get more. Thus it is in seeking to develop his students' whole-hearted interest in his subject as he teaches it—in trying to get his students to want to do what he wants them to do because the undertaking in question is itself interesting to them—that the teacher is likely to be most successful in getting students to learn.

But this is not, unfortunately, the whole answer to the problem of getting students to learn. To show the paramount importance of students' interest in their work is in a sense no very difficult task. To show just how that interest may be aroused and maintained is quite another matter. The latter task presents, indeed, a problem which may properly tax the resources not alone of the general student of education but of the specialist in subject matter. Since I am myself merely a generalist, with no background in the study of engineering, I cannot hope to give an immediate answer to the question in terms of the subject matter of engineering courses. I can, however, suggest certain methods of teaching which have commonly proved valuable in getting students to learn, and which are of such a nature that they can in all probability be readily adapted to the needs of the engineering curriculum.

The most effective teaching is likely, as I have pointed out, to be teaching which arouses the active interest of the student in the subject matter itself. There are at least three major ways of arousing such interest.

One way, paradoxically enough, is not to attempt to rouse interest directly, but to take advantage of interests already present—to *base the teaching as largely as possible on pertinent questions or problems proposed by the students.* The effectiveness which this method frequently achieves springs in part from the fact that matters about which individual students are curious enough to raise questions of their own accord prove in many cases to be matters

which are of interest to other students as well. Questions proposed by students themselves, moreover, frequently arouse more whole-hearted interest than do even the same questions propounded by the instructor. One is immediately well-disposed toward what one thinks of as one's own. Hence a course which treats of such questions gives promise of meeting the interests and needs of the students concerned much more directly than does a course organized quite arbitrarily (from the students' point of view) by the instructor.

This method presents certain complications, however. It demands of the instructor an unusual degree of skill in stimulating his students to raise questions freely, and in adapting to the purposes of the course the questions which happen to interest them. It is likely to result, moreover, in teaching which from the instructor's point of view frequently lacks coherence and unity, and which may omit important items of subject matter, since the units which are taken up are determined by the disconnected and often somewhat irrelevant "spontaneous interests" of the students. Strict adherence to a prearranged course of study, if it means neglect of worthwhile immediate interests expressed by the students, ought obviously never to be insisted on. Yet teaching which is solely guided by students' chance curiosity is no less to be avoided. Hence this single method presents at best only a partial answer to the problem. This much it suggests: that the teacher should be continually alert to stimulate pertinent questions by his students, and that whenever significant questions arise, no matter from what source they may come, he should base his teaching directly upon them even at some sacrifice of systematic procedure.

But the teacher need never be content, fortunately, merely to wait till "spontaneous interests" happen to dawn upon his students. He has it in his own power to create interests quite as "spontaneous" to all appearances, and hence quite as impelling, as the interests which his students come upon by chance. The secret of doing so is to be found in the second of the three major ways of getting students to learn. Briefly stated, it involves simply *"setting the stage" to call forth the proposal of pertinent questions by the students.*

A single illustration of this method will perhaps serve to make it clear.* In a certain course in high-school chemistry the instructor wished to introduce to his students the phenomenon of catalysis. The Dumaresq procedure in such a case would have been simple; he would have had only to assign careful study of certain pages in the textbook, and to insist on thorough mastery of the information

* For this particular illustration I am indebted to Professor Thomas H. Briggs of Teachers College, Columbia University.

which those pages contained. But having become convinced that procedure of the Dumaresq type would be undesirable, the teacher in question adopted a quite different method. He produced in class one morning, without explanation or comment, a pocket cigarette-lighter of a type then in some vogue, which operated through the ignition of alcohol vapor by a catalytic agent brought in contact with the vapor. This lighter he lit, and blew out, and lit again, and blew out, and then started to return it to his pocket. At that point one of his pupils asked to look at it: he gave it to him, showed him how to operate it, and let other pupils crowd about. Various pupils had theories as to how the thing worked. The theories were wrong: the teacher showed them that there was no battery connected with the lighter, no flint, no spark, and no apparent heat until the alcohol was ignited. There were "spontaneous" questions from all sides: "Then how *does* it work?" Whereupon the class began the study of catalytic agents.

There are many phases of the engineering curriculum, I suspect, which will lend themselves readily, in the hands of a moderately ingenious teacher, to such "setting the stage." Demonstrations of unfamiliar processes or of cleverly designed apparatus are likely to be particularly effective in connection with this method. Accounts by the teacher of engineering achievements or engineering phenomena which arouse the students' curiosity through qualities of newness or strangeness may provide an equally promising approach. And the method has in its favor the fact that it need involve no dependence on the merely chance interests of the students, while at the same time it may result in getting the students to learn with as much enthusiasm as if the teacher had taken his cue directly from the students themselves.

There remains still a third way of developing students' active interest—a more obvious way, perhaps, than either of the other two, and yet one which is in many respects more difficult to apply with full success. It consists in *directly proposing topics or problems for study so chosen and so presented as to appeal to students' "natural" interests.* It involves, that is to say, no attempt either to "set the stage" or to ferret out questions which the students themselves happen to have in mind. Instead, it consists simply in proposing a subject for study—"Today we are going to deal with a phenomenon called catalysis"—and in dealing with that subject in such a way as to make it appeal immediately to the interests which all normal people possess: curiosity, liking for the colorful or dramatic, interest in the better understanding of the commnplace or familiar, or any other of that whole range of satisfactions which are so widespread that they are often popularly supposed to have an "instinctive" basis.

The obviousness of this method is amply demonstrated by the fact that it is the method—frequently the only method—which most teachers use. Used by itself, it has the advantage that it allows strict adherence to whatever course of study and whatever time-allotments the teacher finds desirable. In the hands of a skillful teacher, moreover, it may prove to be nearly if not quite as successful as the other methods in holding the students' active interest. But its probable success is exceedingly difficult to gauge in advance. Whether the students will be interested in the learning which it demands of them depends in part on whether the teacher's announcement of the problem itself awakens interest. Does "catalysis," for example, mean enough to the students in question so that they look forward with any sort of positive curiosity to a further understanding of it? If it does, then the mere announcement of the subject may be all that is necessary for a successful beginning. The students' interest depends in part also on their previous experience with study under the particular teacher in question. No matter what "catalysis" may be, have they found in the past that whatever this teacher proposes for their study is likely to be thoroughly worth studying? If so, then here too this method may be successful. But if the teacher is to be able to choose subject matter which in itself awakens the interest and attention of his students, or if he is to deal with that subject matter in such a way as to hold their interest and attention, he must have given long and thoughtful study both to his students and to what he is to teach them. He must know the kinds of things in which his students are likely to be interested—both the things that can be counted on to interest them "naturally" as a group, and the things that may perhaps appeal to certain individuals. He must know also just where, in the whole range of subject matter with which he deals, such things are to be found. And there is no sure way, so far as I know, by which this knowledge can be acquired except through actual trial. The ability to propose problems which will appeal to students' interests, and to deal with those problems in such a way as to maintain the interest which has been aroused, is likely to come only through endless experimentation—through trying out various types of subject matter with various types of students, year by year, and in each case noting the results.

These, then, are three ways to get students to learn: base the teaching on pertinent questions which the students themselves propose; "set the stage" to create active interests; propose subjects for study so chosen and so presented as to appeal to "natural" interest. To the best of my knowledge these are the most effective ways, whether in the teaching of engineering or in the teaching of

any other subject. Their merit lies in the fact that wherever they can be successfully used they result in an attitude toward learning which leads students not merely to learn for the moment, but to hold on to what they learn and to go on learning.

If, as teachers, we had sufficient command of our subjects and sufficient understanding of our students, we might find in these three ways of teaching alone a complete answer to the problem of getting students to learn. But unfortunately both for us and for our students, few of us have at present enough skill in teaching to make these methods alone suffice. We can interest all of our students some of the time in the subject matter which we present to them; we can perhaps interest some small number of our students all of the time; but we find ourselves inevitably confronted with at least some students and some subject matter which quite fail to take to each other despite our best efforts. Must we, then, be content with only a half-way performance?

I have suggested at an earlier point that certain extrinsic interests—rewards, competition, approval of various sorts—may result in getting students to go through at least the motions of learning. Extrinsic interests are never as valuable as interest in learning itself. Since they have, strictly speaking, nothing to do with the things that are learned, they are likely to reduce learning and the direct results of learning merely to an insignificant means, which can be put aside and forgotten as soon as the goal is attained. But extrinsic interests may often make the "motions" of learning less disagreeable than they might otherwise be—may sometimes make them even positively agreeable; and there is always the chance that if the student can be led to go earnestly and not too disagreeably through these motions, he may at length discover the value that rests in the learning itself. Hence it may be worth while to suggest briefly the kinds of extrinsic interests to which students are likely to respond.

Varied and interesting methods of conducting class work represent one kind. The mere fact that students can look forward to occasional relief from the monotony of the lecture method, for example, may do much to make the job of learning more satisfying. Class procedure which gives the students, as well as the teacher, opportunity to be active, may be especially fruitful. Whatever their value as direct teaching devices, group discussions, student reports, class demonstrations, class "excursions," the use of the "case method," the employment of class time for carefully guided study or elementary research, all may provide possibly fruitful sources of interest. Particularly if no one method of teaching is used to the exclusion of others, the mere way in which the class work

is carried on may be an important factor in stimulating students to learn.

The use of attractive illustrative materials may represent a second source of extrinsic interest. Models, diagrams, charts, maps, photographs, have a possible contribution to make toward teaching technique which has by no means yet been fully explored. We may, perhaps, overestimate their worth in many instances as a means of making things clear, but they serve at least to vary the usual purely oral or written presentation of things to be learned. Combined with verbal illustrations which lessen the formality and the possible bleakness of classroom presentation, they may frequently serve as strong immediate incentives to learning.

A third source of interest is to be found in various types of appeal to students' pride in their own accomplishment—through prizes, marks, examinations, and rewards of various sorts, and especially through competition. There is danger in the extensive use of such means as these because of the false motives and false standards of appraisal which they frequently involve. Competition in particular may have exceedingly serious results. There is more than a little reason to suspect, for example, that the "cut-throat competition" which is often deplo[illegible] to in the business and professional world takes more than a little of its spirit from the competitive attitudes fostered in many of our schools. Yet there is no denying that pride in accomplishment may be one of the most impelling forces which the teacher has at his command; and used with due regard to its dangers, it may have exceedingly worth-while results in the classroom.

Still a fourth type of interest may spring from the activity and attractiveness of the teacher himself. Strongly though the professional student of education may deplore the theory that successful teachers are always born and never made, he cannot wholly deny that the successful teacher is likely to have certain qualities which we do not at present know how to "make." Many of these qualities are summed up under the blanket term "personality." But the classroom personality of the good teacher, like the "bedside manner" of the successful doctor, comprises certain things that can be "made." The habit of standing before a class instead of sitting, for example, is a habit which can be acquired; so can the habit of moving about (but not too much), of speaking clearly, of varying one's inflections; so also can the habit of dressing so that one's students may find one "easy to look at" (but not too easy). And all of these things have a part to play in determining whether the job of learning is something to be resisted or something to be undertaken with at least moderate acquiescence.

Finally, direct appeal to a student, or even to a class as a whole,

may sometimes be effective. To learn because someone else wants one to learn, or expects it of one, may not represent the highest type of motive; yet the results of learning thus motivated may be better than the results of no learning at all. Direct appeal does, in any case, represent one possible means for getting students to go through the motions of learning; and the teacher whom students thoroughly respect, and whose high opinion they care for, will often find this means of value.

I have attempted, in listing these major sources of extrinsic interest, to keep always in view the fact that they are means merely for getting students to go through the motions of learning. Getting students actually to learn—if by learning we mean more than "cramming" for a final examination—must always involve awakening their active interest both in the learning itself and in what is being learned. Appeals to extrinsic interests alone can never be counted on to secure this result. Such appeals may, it is true, produce an outwardly convincing show of activity. They may even produce that sort of pseudo-learning which is measured in terms of ability to hand back without fail the verbal subject matter of a given course. But they are, by their nature, unconnected with the subject matter itself, and unless direct interest in the subject matter is somehow aroused, they will succeed only to the extent of producing a mere semblance of learning.

Hence the task of getting students to learn demands the use of two types of appeals. The teacher must first do all in his power to bring out whatever interest is inherent in his subject itself. If he is successful, he will get many of his students—perhaps most of them—to learn through these direct means. But he has always to deal with a certain number of students, sometimes large and sometimes small, for whom he has been unable to make his teaching carry any direct appeal. For such students he must have recourse to the more casual sources of extrinsic interest. Yet for these students also the interest of the subject matter itself must be emphasized, if they are eventually to be added to the number of those whom the teacher has truly succeeded in getting to learn. The measure of the teacher's success is, indeed, the number of his students for whom extrinsic appeals are no longer necessary—the number, that is to say, who learn because they want to, and who go on learning long after their school and college diplomas have been duly signed and sealed.

Is this at length the answer to the problem of getting students to learn? In a world in which teachers were omniscient and omnipotent it might well be the answer. But teachers have limitations, and students are refractory; and at least as often as now

and again it happens that these methods simply do not succeed. What then?

Why then, I think, *make the students work.* Permanent interest usually comes, to be sure, in spite of coercion rather than because of it; so that the methods of Mr. Dumaresq ought fairly to be considered a last resort. Yet Dumaresq's methods had this in their favor—that few of his students could have left his course without respect for the course and for the standards which it upheld. And if Mr. Dumaresq had done more than simply coerce—if he had put his effort as well into an attempt to awaken his students' interest in the subject matter which he was teaching—the learning born of coercion might in some few cases, perhaps, have been at length recognized by its possessors as interesting and valuable for its own sake.

The teacher who grants his own full responsibility for getting his students to learn must recognize his obligation first of all to get them to learn voluntarily. He will need to use to the utmost whatever power he may possess to awaken their interest in the subject matter of his teaching. He will need at the same time to use a wide variety of appeals of an extrinsic nature. If, having employed both these means, he finds himself faced with students who can learn and need to learn what he has to teach them, but who are nevertheless unresponsive to his best efforts, then he still has one further resource. He can make things unpleasant for them if they do not learn, through the various instruments of coercion which educational ingenuity has amply provided. Not until he has finally used whatever coercion may be necessary and effective has he indeed fulfilled his responsibility.

HISTORY OF THE DEVELOPMENT OF GRAPHICAL REPRESENTATION *

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Just when man became conscious of a need for some means other than spoken and written language to express ideas is not known. Nor are we apt to discover even by careful historical research the beginnings of graphical description because the record is gone; yet we may be fairly confident that graphical expression, which is now so universally recognized, must have had its beginnings long before history was recorded.

In the very nature of things it would appear that drawings of some kind must have been used to guide the ancient builders, for drawings are now, and must have always been the necessary accompaniment of constructive endeavor. No one can contemplate the work of earliest times without appreciating that there must have been a carefully thought out plan to guide the work. In just what form this plan was recorded, there is of course no record; it may have been but a crude sketch pictorially representing the idea, and leaving much to the initiative and imagination of the builders; or it may have been an artistic rendering dealing largely with appearances and meagerly with details; or it may have been a cryptic expression based on a system of description now lost like the languages of the ancient tribes; yet these representations served and functioned much as do modern drawings, if results may be used as a measure.

It seems not unreasonable to believe that Tubal Cain—who is alleged to have been the first teacher of shop work according to Genesis 4:22—set up his forge on the plains of Mesopotamia and began his lessons in the working of brass and iron, he must have used some means of graphical representation to convey his ideas. These may have been no more than crude diagrams in the sand, yet they served a purpose. Nor does an examination of some of the archaeological discoveries from the biblical cities of Palestine leave one in doubt about the ability of an ancient people living as early as 2000 B.C. to portray a story in graphical form. Meager as such

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evidence is concerning the beginnings of a science which is now a controlling force in human enterprise, yet it is all that remains to show that even in those early days the spoken and written language needed to be supplemented.

The first positive evidence which definitely establishes the fact that drawings were used to guide constructive undertakings, is found in the writings of Vitruvius (63 B.C.–14 A.D.) who states—"The architect must be skilful with the pencil and have knowledge of drawing so that he readily can make the drawings required to show the appearance of the work he proposes to construct, . . ."

Other references in Vitruvius definitely establish the fact that draftsmanship was recognized and that drawings were the method used to convey structural ideas.

In about 100 B.C. Frontinus, who became "Curator Aquarum," relates how he had *plans* made of the Roman aqueducts.

In commenting upon these facts, Professor Alexander P. Gest states: "I have no doubt that there must have been at least a practical knowledge of drafting among the Greek and Roman engineers, and it is hard to imagine the Greek geometers without some sort of Descriptive Geometry."

Of the drawings of Leonardo da Vinci, more is known: that he understood and practiced representation by the method of perspective, is clearly evident, but no record of representations made by what came to be known as orthographic projection remains. Not only was da Vinci a great artist, but he was also a great engineer. His treatise on painting which included an exposition of the theory of perspective, doubtless exercised a great influence on the art and artists who were his contemporaries; and his vast collection of sketch books is filled with sketches of assembled machines and their details. Whatever may some day be discovered about the mechanical proficiency of Leonardo's time, be assured from this great collection of ideas so marvelously expressed in graphical language, that he forecast the mechanical development of the years which followed.

In 1587 projects for the publication of Leonardo's manuscripts began, but it was 1651 before the treatise on painting which contained his exposition of the theory of perspective was published. This date fixes the first publication of the theory of projection. This theory was of course, scenographic projection; of Leonardo's knowledge of orthographic projection—if indeed he had any—there is but slight evidence.

Reference is made in Usher's "The History of Mechanical Inventions" to a "selection from the mechanical drawings" in Leonardo's various manuscripts, and relates how these passed from one owner to another, from Italy to Spain, to England and

back at last to the Ambrosian library at Milan in 1636, where they remained until the invasion of Napoleon. "They were then brought to Paris and many of them never returned." Whether the "mechanical drawing" referred to here means graphical representation of the type now called orthographic representation, or whether "mechanical drawing" in connection with Leonardo's work means graphic representation by the method of scenographic projection made with *mechanical aids,* is not clear; the latter assumption seems more likely to be the case.

It is not so essential to establish in this record the type of graphic representation used at this period, as it is to establish the very important fact that during Leonardo's active life—from 1475 to 1516—he practiced and taught a method of graphical description which had for its direct purpose the recording and conveying of ideas on mechanical subjects.

Passing now to the period which followed Leonardo, and preceded the discovery of the science of orthographic projection, some evidence is to be found showing that drawings even then were commonly used in constructive work. While most of the references are to "architectural drawings," and most of the structural activity of that period centered around public buildings and civil engineering works of a public character, there is reason to believe that graphical representation was the common source of information used to guide the work.

There was in existence a few years ago, a set of drawing instruments bearing the date 1701, which in many details bears a striking resemblance to our modern high grade sets. In workmanship alone, here is testimony concerning the age of drawing of a striking character; for these tools obviously were the product of many years of use and development, both in the art of instrument making and in the art of draftsmanship for which they were designed.

In 1715 Brook Taylor published the first book in the English language on perspective which was entitled: "New Principles of Linear Perspective, or the art of designing on a plane the representations of all sorts of objects in a simpler method than has yet been done."

In 1726 Batty Langley published the first book on what has developed into Engineering Drawing. The book, a beautiful example of printing—hand set type, and hand made paper—is called "Practical Geometry, Applied to the useful arts of Building, Surveying, Gardening and Mensuration." It is calculated for the service of "Gentlemen" as well as "Artisans," and contains four parts, the most significant being: "The various orders of architecture, laid down and improved by the best masters; with ways of

making draughts of buildings, gardens, groves, fountains, etc., the laying down of maps, cities, lordships, farms, etc."

The book is illustrated by copper plates engraved "by the best hands" and is indeed remarkable and delightful proof that long before descriptive geometry was even discovered, mankind recognized how difficult a subject it was destined to become. According to B. Langley in 1726: "The subjects of the present treatise, on account of their *antiquity,* usefulness and entertaining variety, having been the delight of the greatest masters in knowledge, thro' various ages, are, it must be acknowledged, transmitted to us in a suitable degree of perfection. They have indeed been largely treated of by various hands, but generally in a theoretical, rather than in a practical manner, so as to appear somewhat intricate and obscure to such as were not acquainted with the principles of mathematics, or have not applied themselves in earnest thereto. My design therefore is to treat of architecture, gardening, mensuration and land-surveying, in a method as easy and intelligible as it is new and generally useful. I shall begin with the fundamental, or first principles of these several arts, and gradually conduct my reader from the easiest parts of 'em up to the hardest, taking particular care all along to let him see the *utile* as well as the *dulce* thereof; the fruitful practice, and not the barren theory only. From a failure of authors in this point, I apprehend it is that these arts are at present much less cultivated than they merit. An author cannot do them greater justice, than to paint them as they are, most useful and delightful employments; of great importance in human life. To convince the world of this truth, as it is the design, so it wou'd be the highest recommendation of the present treatise. And this I can sincerely say, that I have had a view thereto thro' the execution of the whole design. I shall not therefore offer any recommendation of the arts themselves, which want no able hand to set them off with colours, and the winning charms of rhetorick; but leave my reader, from the plain, naked, artless facts and observations he will meet with in the work, to determine of their merit. And I am greatly equitable, and more unexceptionable procedure than to write, as the usual manner is, an encomium of arts I treat of, in order to recommend the work. For if the book cannot be supported by its own merit, I am sure a panegyrick upon its subject will but render it the more ridiculous and contemptible. All that I request is a fair and candid perusal. I desire only that my reader wou'd come with a mind prepared not to be startled, or prejudiced against the author, by the appearance of novelty back'd with reason; tho' it at first sight shou'd seem to thwart some current and prevailing opinions. This were a temper that wou'd forever exclude the light, and dronishly remain con-

tent with whatever doctrine happens to have its run. But we of late have seen such successful inrodes made into opinions once thought just, that we cannot be too suspicious of our entertaining establish'd errors for truth, and shutting our eyes against plain fact and obvious reason. 'Tis not that I pretend to a faculty beyond that of others in discovering the truth in the particular subjects I have here treated; but my genius leading me to such kind of studies, I hope I may be allowed to have observed the common things and to make my own use of them. If what I alledge to be true, (for which I always give my reasons) the world will have the advantage; but if it shall prove to be false, I shall willingly bear the blame: Only I make this request, that I may be censured by the proper judges, and such as have been conversant in the same kind of studies with my self; otherwise the world, I hope, will agree with me, that I am condemn'd unjustly. That the reader may form the better judgment of the performance, he may be pleased to take the following account thereof.

"Geometry being the basis of architecture, gardening, mensuration and land-surveying, (which are the subjects of this treatise) I have in the first part, laid down all the most useful and necessary geometrical definitions, problems, theorems, and axioms, that are absolutely necessary to be well understood by every one who desires to be a complete artisan, and those in a most concise and familiar manner. The second part contains the application of the first to practice in the geometrical construction of all kinds of scales for the delineating, and mensuration of all sorts of plans and uprights, and of the *Tuscan, Dorick, Ionick, Corinthian, Composite, French* and *Spanish* Orders of architecture, with their derivation, proportion, etc., in general. And seeing that neither ancient or modern architects have yet agreed on the measures of the principal parts of entire columns: I shall therefore before I proceed any further, demonstrate the same particularly."

Commenting upon the forces which gave rise to the discovery of the science called descriptive geometry, Alexander W. Cunningham in his "Notes on the History, Methods and Technological Importance of Descriptive Geometry" states: "Architecture and stone masonry have always necessitated the study of geometrical drawing. I am aware that Mr. Fergusson in his History of Architecture (page 665) ignores the idea of any great attention having been paid to graphical designs in the erection of the early Gothic Cathedrals. But it appears to me that Mr. Fergusson, in maintaining (what is probably quite correct) that the nomadic masons were not the architects of these Cathedrals, but that the Bishops, abbots, and accomplished laymen, 'not specially educated' to the profession of architecture, and qualified only by 'talent and good

taste,' fulfilled this office, goes too far when he says that, 'without making drawings, guided only' by general directions as to the plan and dimensions, the 'masons might proceed with the work.'

"I cannot, however, afford space to discuss such questions, but the remark of Lorenzo de Medici, already referred to, is worthy of note. Mr. Fergusson, however, referring to Masonry itself, says (page 666)—'When freemasonry became so powerful as to usurp the designing as well as the execution of churches, there was an end of all art, though accompanied by some of the most wonderful specimens of stone-cutting and constructive skill that ever were produced.' Now this art of stone-cutting deserves to be particularly mentioned as having given birth to many ingenious, graphical, and constructive operations, more especially as, for obvious reasons, it was practically associated with the art of dialling. Geometrical methods, both graphical and constructive, which in the middle ages and early modern times had been cherished as secrets pertaining to the masonic craft, were in the 17th and 18th centuries expounded in treatises on the art of stone-cutting.

"I regret that it is impossible for me at present to notice the development of graphical geometry with respect to Shipbuilding, an art especially dependent on scientific means of graphical representation. I pass on to Fortification. . . .

" . . . Accordingly, towards the close of last century, the French mathematician MONGE was led, from the consideration of certain problems in fortification, to generalize all the isolated method hitherto employed, not merely in fortification, but in perspective, dialling, stone-cutting etc., into a theoretical code, which he termed *la Géomètrie Déscriptive,* and which was designed to supply the means of—(1st.) preparing on uniform principles the working drawings necessary in the various arts; and of (2d.) graphically solving problems in solid geometry, by general methods, capable of the most extensive practical application.

"The name of Monge is so inseparably associated with Descriptive Geometry, and the development on this basis of French technical education, that I need offer no apology for giving some account of his life and labours. The best notice of these which I have met with, in any English work of reference, is that contained in the old Penny Cyclopaedia. Those who desire fuller particulars should consult DUPIN'S *Essai historique sur les services, et les travaux scientifiques de Gaspard Monge* (Paris, 1819). Indeed I may say that this work deserves the attention of every one who wishes to understand the growth of the French system of technical education.

"GASPARD MONGE was born at Beaune in 1746. Having early given evidence of distinguished mathematical talents, both as a

student and teacher in the College at Lyons, he obtained an appointment as draughtsman in the military school at Mezieres. Here he distinguished himself by his geometrical solutions of questions in Defilade (Defilement), a term given to the general problem of securing in the design of a work of defence, thrown up on an irregular site, the utmost amount of cover compatible with a certain moderate 'relief' or height. 'By applying,' says Dupin, 'his mathematical talents successively to different questions of an analogous character, and generalizing in every instance his modes of conception and operation, he succeeded at last in establishing a code of doctrine—his Descriptive Geometry. . . . But how many obstacles had he to overcome before he could overthrow the scaffolding of a mass of incoherent practices, and substitute for them a simple and general method, which left no longer a vantage-ground for charlatanism, or an asylum for the mysteries of empiricism!' . . .

"Now so great was the admiration accorded to Descriptive Geometry on its first promulgation by Monge, that many were disposed to regard it as a real means of extending the science of Geometry. This, however, is not the case. The mistake arose probably from overlooking the fact that a large amount of rational geometry was necessarily mixed up with the exposition of mere descriptive operations; and, more particularly, from not clearly perceiving that truths may be deduced from the *Theory* of projection, without any necessity for graphically exhibiting them by the *Methods* of projection."

Coincident with the development of the science of orthographic projection, came the beginnings of "the interchangeable system of manufacturing," and the establishment of technical education in the United States.

Even while Monge was pleading for the study of descriptive geometry, as a means of stimulating manufacturing in France, Thomas Jefferson, then Minister to France, in 1785 wrote in describing the manufacturing of guns: ". . . it consists of the making of every part of them so exactly alike that what belongs to any one may be used for every other musket in the magazine. . . ." In another letter written later to President James Monroe, Jefferson stated that Le Blanc, a French mechanic, had extended his system and that he, Jefferson, was hoping to get him to come to the United States. That Jefferson grasped the advantages of this system of manufacturing is evident from these early letters, that his interest continued is shown by a quotation from a letter he wrote in 1801 about Eli Whitney: "He has invented molds and machines for making all the pieces of his locks, so exactly equal that take one hundred locks to pieces, and mingle their parts, and the one hun-

dred locks may be put together by taking the pieces which come to hand."

In England during the period just preceding and following Monge's discovery, such men as Sir Christopher Wren, Smeaton, and Telford were making use of the empirical knowledge of their times in describing graphically cathedrals, light houses, and public works. Smeaton is known to have taken down the interior walls of a cooperage in order to lay out on the floor his design for the Eddystone Light which he began in 1757. Telford lived long enough after the publication of Monge's work to have been influenced by it, for in connection with some of his work in 1821 a three view drawing was printed. During this period, there seems to be abundant record to show that drawings were used in connection with public work of an architectural and civil engineering character, but we should credit James Nasmyth (1808–1890) for his influence in applying this new language to the description of machinery.

The story of the steam hammer that Nasmyth sketched in 1839, is now a classic, but of his ability as a draftsman the following is of interest: "James Nasmyth was the tenth in a family of eleven children. Like all of his brothers and sisters, he inherited his father's artistic tastes. If he had not become an engineer he would probably have become distinguished as an artist. To the end of his life his skill with his pencil was a constant source of pleasure and convenience. The notebook in which the later record of his mechanical ideas is contained, is crowded with funny little sketches, landscapes, little devils and whimsical figures running in and out among the calculations. . . ."

In France and in Germany Monge's descriptive geometry became very quickly a part of the national education plan, and in 1816 Claude Crozet introduced the subject into the educational scheme of the United States at West Point. After graduating at the Polytechnic School in Paris, Crozet had been artillery officer under Napoleon. From 1816 to 1817 he was assistant professor of engineering at the Academy, and from 1817 to 1823 full professor. E. D. Mansfield has given us some interesting recollections of Crozet's earliest teaching at West Point.

The junior class of 1817–18 was the first class which commenced thoroughly the severe and complete course of studies at the Academy. Of Professor Crozet, Mansfield says that he was to teach engineering, but when he met the class he found that he would have to teach mathematics first, as not one of them had had the necessary preliminary training in pure mathematics for a course in engineering. "The surprise of the French engineer, instructed in the Polytechnique, may well be imagined when he commenced

giving his class certain problems and instructions which not one of them could comprehend and perform." "We doubt," says E. D. Mansfield ,"whether at that time more than a dozen or two professors of science in this country knew there was such a thing (descriptive geometry) ; certainly they never taught it, and equally certain there was no textbook in the English language."

This science, founded by Monge, was then scarcely thirty years old. Crozet meant to begin by teaching this branch, but a new difficulty arose. Just then he had no textbook on the subject, and geometry could not be taught orally. What was to be done? "It was here, at this precise time, that Crozet, by aid of the carpenter and a painter, introduced the blackboard and chalk. To him, as far as we know, is due the introduction of this simple machine. He found it in the Polytechnic of France."

In 1821 Crozet published his *Treatise on Descriptive Geometry,* for the use of cadets of the United States Military Academy at West Point, thus antedating all but the original books on the subject. The first eighty-seven pages were given to the elementary principles, and the next sixty-three pages to the application of descriptive geometry to spherics and conic sections. This is, according to our information, the first English work of any importance on descriptive geometry and the first book published in this country.

Even before descriptive geometry was introduced into the curriculum at the Academy, Christian Zoeller was made instructor of drawing in 1807. Later he was made professor and is doubtless the first teacher of drawing in our first school of engineering. Probably on the walls of West Point is a more complete record of the stages through which graphical representation has passed, than exists anywhere in this country. Although it is recorded that Christian Zoeller was an instructor of drawing at West Point in 1807, it must be remembered that painting and other forms of graphical expression were then taught to the embryo soldiers and among these records on the walls of West Point is a sketch by Whistler, who was once a cadet.

During the years 1802–1824, the United States Military Academy established the beginnings of engineering education in this country. At the same time in New England the technique of interchangeable manufacturing applied to guns and locks by such men as Whitney, North, Jerome, and Colt was creating a demand for scientific knowledge. This demand was amplified by conditions following the war of 1812: The exhaustion of the soil by unscientific methods of agriculture, the demands for better systems, the trend toward new lands in the West, all tended to focus attention on the need for scientifically trained leaders.

Commenting upon this situation Dr. Charles R. Mann, in Bul-

letin No. 11 of the Carnegie Foundation for the Advancement of Teaching, on *A Study of Engineering Education* states: "In spite of the wide-spread recognition of the need, the Rensselaer Polytechnic Institute remained for twenty-three years the only school of its kind. At length in 1847, thru private benefactions, the Lawrence Scientific School was established at Harvard and the Sheffield Scientific School at Yale. The University of Michigan also voted the same year to offer a course in civil engineering. These were the only* additional engineering schools opened before the Civil War, and they had a hard struggle for existence because their aims seemed dangerous to academic traditions.

"During the Civil War Congress passed the Morrill Act (1862) granting federal aid to the several states for founding colleges of agriculture and mechanic arts. State legislatures that had for years been deaf to all appeals now quickly accepted the federal grants and voted to create the new type of school. Established colleges caught the spirit and added departments of engineering. The four schools of 1860 increased to seventeen by 1870, to forty-one by 1871, to seventy by 1872, and to eighty-five by 1880."

The importance of drawing and descriptive geometry in these pioneer civil educational institutions was early recognized and in 1849 the revised curriculum of Rensselaer devoted four courses scattered throughout the three year curriculum to drawing and descriptive geometry; in 1865 the Massachusetts Institute gave two courses in drawing and two courses in descriptive geometry; in 1867 drawing was mentioned in the curriculum of the University of Illinois, twice, descriptive geometry twice, and shades, shadows and perspective once. Among "the qualifications requisite for a candidate for the degree Civil Engineer" the Rensselaer school stated: ". . . he must be perfectly familiar with plotting and business drafting."

Of the teaching of descriptive geometry, at these institutions and of the ideals and objectives of the pioneer teachers: Crozet, Davies, Church, and Warren, fortunately there is adequate record in the prefaces of their valuable books on descriptive geometry. Of the teaching of mechanical drawing, as it was beginning to be called, very little is known until the middle of the nineteenth century.

In 1834, T. Sopwith, an Englishman who described himself as a "Mine and Land Surveyor," published a treatise on *Isometrical Drawing,* which method of representation he advocated as applicable to ". . . perspective views and working plans of building and machinery." In this excellent book the author clearly

* Union College offered courses in engineering in 1845, and Brown University in 1849.—AUTHOR.

demonstrated his knowledge of orthographic projection, and advocated isometric *drawing* in preference to isometric *projection*, and that he favored isometric representation as having "many peculiar advantages which cannot be obtained by any other method." While we are not now concerned with Sopwith's championship of isometric drawing, we are enlightened thereby because his thesis no doubt was the outgrowth of a need for a *better* method of graphic representation than was commonly used. And this we may infer from the following: "For Plans and Elevations of Buildings, and for working details of Machinery, Isometrical Drawing possessed such decided advantages, that a more extended knowledge of its principles cannot fail to ensure its almost universal application, in preferance to every other mode of *perspective drawing.*"

That a need for textbooks existed at this time, is voiced by Wm. Minifie, who published one of the earliest books on drawing which might be called a textbook. In 1849 Minifie states in his "Geometrical Drawing": "Having been for several years engaged in teaching Architectural and Mechanical Drawing, both in the High School of Baltimore and to private classes, I have endeavored without success, to procure a book that I could introduce as a textbook: works on Geometry generally contain too much theory for the purpose, with an insufficient amount of practical problems; and books on Architecture and Machinery are mostly too voluminous and costly, containing much that is entirely unnecessary for the purpose. Under these circumstances, I collected most of the useful practical problems in geometry from a variety of sources, simplified them and drew them on cards for the use of the classes, arranging them from the most easy to the more difficult, thus leading the students gradually forward; this was followed by the drawing of plans, sections, elevations and details of Buildings and Machinery, then followed isometrical drawing, and the course was closed by the study of linear perspective and shadows; the whole being illustrated by a series of short lectures to the private classes. . . . In conclusion, I must warn my readers against an idea that I am sorry to find too prevalent, viz.: that drawing requires but little time or study for its attainment, that it may be imbibed involuntarily as one would fragrance in a flower garden, with little or no exertion on the part of the recipient, not that the idea is expressed in so many words, but it is frequently manifested by their dissatisfaction at not being able to make a drawing in a few lessons as well as their teacher, even before they have had sufficient practice to have obtained a free use of the instruments."

With the single exception of a slight reference to T-square and drawing-board in Langley's book on *Practical Geometry* published

in 1726, Minifie is one of the first writers to give any extensive discussion of drawing tools or of how to use them, and so far as I can learn this text bears to the subject of drawing in the United States about the same relation as does Crozet's to descriptive geometry.

The first half of the nineteenth century might well be called a formative period in the development of graphic language: the science of orthographic projection was discovered and knowledge of it was disseminated; textbooks on drawing and on descriptive geometry were written; schools were established and technical education was founded; and even more important for the future a pressing need for technically trained leaders and a growing demand for increased production focused attention upon the new sciences by means of which these ever increasing needs for expansion were to be satisfied.

The second half of this century was a period of growth, of change, of development, and of expansion so colossal and so fascinating that it deserves thoughtful study by every engineer. This era of national adolescence has been referred to vaguely and even wistfully by some as "the good old days." May I pause to point out just a few of the very high lights and very deep shadows of this epochal time?

Socially we were a people of little culture, a people of great wealth and of no knowledge of how effectively to use it. Our educational opportunities were at what would be called now a low high school level. Our ethical standards of conducting business were on a par with our political standards and both were founded on bribery and corruption.

Even as early as 1865 we were a large manufacturing nation and the enormous expansion of industry which followed the Civil War has never ceased.

Agriculture in 1870, even as now, was passing through a crisis which threatened the political stability of the country. Our national life was thrusting westward toward new land, new resources and new problems.

There was a calamitous panic, an upheaval of labor, and an industrial revolution.

Couple all this, if you will, with the tremendous effect of new inventions in steel making, in the development and application of power, in the national transportation systems, with the discovery of vast reservoirs of national wealth in coal, iron, oil, water power, and new agricultural areas, and with the benefits which were being reaped from advances in sciences, both pure and applied, and you have the situation which made the United States what it is to-day.

Perhaps the growth, the change, the development which is here

just hinted at may be more strikingly brought into the true relation it bears to the colossal economic change which was the product of this fifty years by the statement: "During the years from 1870 to 1895 the occupation of a large majority of persons employed in the production, the transportation, the marketing of almost *every article in common use,* was more or less modified."

During the period from 1850–1900 the whole scheme of graphic representation underwent the same colossal change which was common in all lines of endeavor. Military and Civil Engineering ceased to be designations sufficient to indicate the character of constructive undertakings, and engineering and engineering education became divided into branches. With each of these branches of engineering there arose a need for a kind and style of drawing in keeping with the nature of the undertaking, and thus came the day of specialization.

Along with, and stimulated by these developments and changes in the art of graphic representation, came improvements in drafting materials and instruments, the establishment in this country in 1850 of the pioneer and now sole surviving American factory for manufacturing drafting instruments by the Alteneder family, the discovery about 1840, and the introduction to the engineers of this country in 1878 of the blue print process of reproduction. During the first part of the 19th century "Draughtmanship" was an art expressing itself in fine lines, shading both by lines and by washes, ornate borders, fancy lettering and the use of colors; but with the introduction of the blue print process, all this was changed.

With this epoch-making event modern drafting came into being. The demands of the high-speed industrial organizations, of which the drafting room found itself a part, became so great that shading, fancy borders, and ornamental lettering could no longer justify the time required to execute them; drawings became plainer and even severely plain until now only that drawing which tells a complete story in the fewest lines is considered acceptable. Even the name which describes the making of a drawing has suffered from this process of pruning; the art of *draughting* has been completely lost but the business of drafting has been discovered! This change is not to be deplored, however; the function of drawing is to produce and record results, and since the results obtained by the use of modern drawings are unquestionably superior to those of earlier times, it is fair to assume that a part at least of this improvement is due to the change in drawing while at the same time it can be admitted candidly that the greater part is due to improvements in manufacturing processes. Drafting and manufacturing are so interdependent that development in the one is always accompanied by development in the other.

It was about this time that it became recognized that a drawing could accomplish what formerly had been considered, if not indeed impossible, at least impracticable—that is, infallibly to convey information to a workman; and with this fact established, model-making as an element in production became one of the lost arts.

The fact must not be overlooked that once established as the dependable means of conveying facts, drawing played an important role in establishing our present scheme of production, and as the demand upon the drafting rooms grew it must be recorded that draftsmen faced challenges at that time as stupendous as those thrown down before any group of workmen engaged in keeping pace with the colossal demands of production. More and more it was expected that information from the drafting room would be reliable, complete, and not ambiguous. More and more were draftsmen called upon to demonstrate that the so-called "unproductive" drafting room was worth what it cost. Caught as it were, between the pressure of demands for results, and the problem of securing results in the face of lowering standards among the craftsmen who were responsible for the construction, the modern drafting room passed through a formative period which was revolutionary.

Thus it was that in the late nineties the modern drafting room came into being as a part of the national industrial organization, and came to be accepted as an integral element in the scheme of production. And as a result of all this, draftsmen became conscious of themselves and of their profession.

One might almost be permitted to call this period between 1890 and 1900, the "humorous" or even "literary" period in the development of graphic language because of the pages and pages of words which were published in all seriousness about matters which now seem so unimportant. It must be recalled, however, that at this time the "college-trained" draftsman was making his first bow to the industrial world, and that he was being received by his "hard-boiled" shop-trained contemporaries with snorts of derision and a contempt born of a vague alarm that here indeed might be a new menace!

Be it also remembered that these college-trained draftsmen were far from the type we are now so proud of. These men had been trained to make drawings wonderful in appearance, they could shrink paper on the board, they could make lettering look better than news print, they could use water color and india ink wash, but when it came to making a drawing which described the shape and size of an object informing the workman simply and directly what he needed to know about finish, material, and other pertinent items, they should not be compared with that class of veterans who had

earned their places in the drawing rooms by virtue of sheer merit and long experience.

Remember too, that the textbooks of those days were written by "college men" or "professors" and no amount of quotation marks in this manuscript could convey the contempt with which their efforts were viewed by the "practical" draftsmen. Nor were these men among themselves in agreement, nor were their views always practical. Following in large measure the traditions of earlier works such books dealt generously with geometrical construction, practical descriptive geometry, exercises in the use of instruments, and meagerly, if indeed at all, with the application of such knowledge to graphical description. These "old timers" even resented somewhat new ideas as may be inferred from this comment by MacCord about drawing ink: "The best is of Chinese manufacture and comes in sticks or cakes of various sizes and forms; this is to be simply rubbed up with water to any desired density. The labor of preparation, slight as it is, is to some persons a great bugbear; and in response to their demands various 'liquid India inks' are offered for sale; the bottles, when properly cleaned, are good; which is more than can be said of the contents."

In those days draftsmen and professors alike were still arguing about the proper form of delineation, about the proper arrangement of views. This period was about the turning point of that fine old war between those who favored the *first quadrant* against those who favored the *third quadrant* method or representation. To quote one author: "By this plan the horizontal and vertical projections are made with the object at rest on the horizontal plane. To illustrate, a brick will do. First, plan, brick lying down flat. View from top shows it eight inches long, four inches wide. Second, side elevation, board shoved behind brick, and figure of brick marked on it, 2 inches high, 8 inches long. Third, end elevation, board raised on the right and figure of brick drawn on it, 2 inches high, 4 inches wide. This is the same effect as though the draftsman marked around the brick as it laid flat, then turned it up, directly on the side from him, scratched around it again. This scheme discountenanced acrobatism and all manner of inebriated posturing in the object and conserved for it a respectable representation. . . ."

Commenting somewhat tartly upon articles similar to the foregoing on projective drawing, Oberlin Smith wrote in 1895: "The writers of the recent essays upon the above seem to dwell particularly upon the doctrines of descriptive geometry, although some of them ring the changes upon other imaginative methods of conceiving what a drawing means, such as walking around the object represented, or climbing up on top of it, or burrowing underneath

it, or looking at it through transparent paper, or through glass, or having its various sides depicted upon paper which may be supposed to be wrapped around it, and which afterwards may be peeled off, after the manner of skinning an onion, etc.

"The imagination required to see things in mid-air, where they do not exist, is a very desirable quality which is posssessed as a gift of the gods by many inventors, by chess players who can conduct several games at once with their eyes blindfolded, and in a lesser degree, by ordinary geometricians, by well-trained draftsmen, by good whist players, and also (shall I say it?) sometimes, perhaps, by theologians and commercial travelers.

"It seems to me, therefore, that if we desire a simplicity adapted to untortured, if not untutored, imaginations we must totally abandon for practical work the complexity of two ideal planes and their four ideal angles, with the conception of the object seen beneath the paper instead of above it, etc. If, further, we abandon the still more puzzling ideas of walking around or climbing over the object, or unfolding its skin, we will probably come down to the simple conception of the object, or a model thereof, of the proper size, lying upon the paper. To get additional views, we must either *revolve* it directly by merely rolling it over, or, by the method last described, we must both roll it over and slide it to a considerable distance from its original position. It does not appear to me, *as probably it does not to the great army of my fellow believers, that there can be two answers to the question as to which is the simplest and therefore the best of these two methods.* . . .

"In some recent articles upon this subject, it has been stated that the majority of our best shops are now using the third-angle, or indirect method. If it be the fact that the first-angle, or direct method, has been gradually dying out, the melancholy probabilities are that it will die still more. When its disease becomes absolutely mortal, it will be only the proper thing for the army of '*direct*' people to gracefully surrender to the larger army of '*indirect*,' learning the habits of a lifetime over again, that a common practice (even if not so good as is something else, in the eyes of some of us) may obtain throughout the earth. *Such uniformity is certainly of great importance,* not only as a matter of convenience, but of actual saving of expense in the avoidance of mistakes, etc., and should undoubtedly be aimed at by all of us as early in the future as is possible.

"This question of which way to project cannot in the nature of things be of such very great importance in itself, like theology, or so many good people would not differ regarding it. Let us then all strive to come to a *common practice* in the matter and meet upon common ground of *direct revolution* if we can, or *indirect* if we

must. Let us remember, however, that America is all the time becoming less provincial and that this common ground should be *international,* rather than merely *occidental.*"

Thus, even so early as 1895, is found a far-sighted plea for standardization and for uniformity. Amusing many of these ideas of graphic representation now may seem, yet out of the unrest and dissatisfaction here expressed, gradually evolved a new period in the development of graphic representation, and a greater stability in the art of graphic expression.

Among the most *significant* and *far-reaching influences* in the development of *graphical representation* was the acceptance, early in the *twentieth century,* both by teachers and draftsmen, of the *third angle method of representation.* With the moot question of how views should be arranged, disposed of, and settled for all time, theorists and practitioners alike, turned their energies in the years which followed, to the refinement and improvement of drawing as a language. As a natural result, more and better literature on graphical representation was published both in the form of textbooks and in magazine articles during the first quarter of the twentieth century than had appeared in any similar period throughout the entire history of the subject.

Books on descriptive geometry designed to make the subject *easy to understand,* to illustrate the *applications* of descriptive geometry, and presenting the subject from the standpoint of the *third angle* appeared with almost clocklike regularity. But aside from the improvement in *presentation,* and in the study of *applications,* no great advances were evident in subject matter. *The pioneer Monge* had covered the field and one hundred and thirty-five years of scrutiny and research has added but little to his extraordinary and comprehensive achievement.

In the textbooks on drawing, however, great and noteworthy advances were made during this period. Technical education was passing out of its preliminary adolescent stages and the application of science to industry was becoming an actuality and not merely a dream.

Not only as a result of this but also because of the recognition industry was bestowing upon education in general, college trained draftsmen were finding a place in the industrial world and their influence was being felt in the literature of graphical representation. Indeed many of the teachers of engineering subjects were drafted from industry and after having learned the limitations of their own college training began a new era in technical teaching. For the first time, the whole subject of graphical representation: the theory of projection, the application of this theory to shape description, size description, and the application of shape and size

description to the general field of graphic description were joined to the old pedantic routine of geometrical drawing and the manipulation of drawing tools to make a comprehensive and adequate treatment of graphic representation.

Men like Anthony, the Reid brothers, Jamison, Fellows, and French, published books on drawing which explored the field as never before, and which adequately covered the subject in all its phases. Along with this development in drawing literature other books than texts on "mechanical drawing" appeared, and the literature of graphics began to make its appearance in books covering the fields of structural, architectural, topographic, machine drawing and, later, an even newer branch covering the subject of the technic of presenting statistical and technical data in graphical form.

For a number of years both teachers and practitioners had been feeling a mild dissatisfaction with the inherited and misleading name *"mechanical drawing,"* and with the more evident divisions of graphics into specialized branches it was inevitable that new names should appear. Professor Anthony's designation of *"graphics"* and Professor French's name of *"engineering drawing"* were both attempts—and successful attempts—to establish a fact known but never properly presented, that drawing of whatever kind, *is a graphic language,* and to each of these pioneer leaders the profession owes great acknowledgment.

No sooner had the idea of a graphic language been established, than dissatisfaction with and disapproval of the lack of standards, the absence of uniformity, and the freedom with which ideas were conventionalized began to be published, and at once received endorsement. Like the weather, a great deal was said about it and nothing at all was done until under the impetus of the "simplified practice" movement, the American Standards Association, with the Society for the Promotion of Engineering Education and the American Society of Mechanical Engineers as sponsors, organized a committee to establish standards for drafting and to bring such standards into agreement. This committee has been at work now since 1926 and is about ready to present in final form a recommendation for uniformity which in the end will make drawing what it should be—a truly *universal language.*

Reviewing very briefly the development outlined here, four rather outstanding periods are evident: *The first*—antedating 1750 and reaching back into early times—reveals little but a conviction that even in this early day the value and use of a graphical means of conveying ideas were appreciated. The outstanding event in this period is the work of Leonardo da Vinci and his contribution to the science of perspective. *The second,* one hundred years in

length, is more productive. Monge discovered the science of orthographic projection, early engineers began to use methods commonly used to-day, engineering education was established, and teaching the graphic language began.

The third period, from 1850–1900, witnessed the establishment of drafting as an integral part of the nation's production system, and the perfection and development of the materials of representation.

The *fourth* and *final* period—that in which we now find ourselves—is more significant than any. The science of graphical representation definitely is moving toward standardization, its literature is well-founded and well-defined, its teaching is on a firm basis; knowledge of its value is recognized, and its use in engineering and associated lines of activity is increasing.

What then of the *immediate future?* If the past teaches any lesson in regard to the future of graphics in general, if trends mean anything and are correctly interpreted, then the future will bring about an *increasing use of graphics* in all fields of endeavor, will witness a *wider* and more *general knowledge* of the graphic language, will insist upon *greater simplification, more abbreviation,* and *absolute uniformity* in representation. And if teachers of the graphic language are true to their responsibilities this will come about *soon* as a result of their efforts not only for the improvement of graphics as a *language,* but also as a result of their conviction that a knowledge of drawing is of value and should be acquired early in life.

OUTSTANDING ENGINEERS

Officials of the various American Engineering schools were recently asked to point out the men who have, in their estimation, been the *outstanding engineers* of the past twenty-five years; also those who might fairly be considered the ***greatest engineers of all time.*** We are grateful for the generous response, and also for many courteous refusals to reply to so indefinite an inquiry.

Many who have seen a tabulation of the replies have asked us whether we specified *American* Engineers. No such limitation was set, or implied.

Greatest Engineers of All Time.
78 names were mentioned.

James Watt
Leonardo da Vinci
Thos. A. Edison
William B. Eads
Ferdinand de Lesseps
Chas. P. Steinmetz
George Westinghouse
John Ericsson
Archimedes
Lord Kelvin
John L. Roebling
George W. Goethals
John F. Stevens

Outstanding Engineers of the Past Twenty-Five Years.
71 names mentioned.

Herbert C. Hoover
Chas. P. Steinmetz
Thomas A. Edison
John F. Stevens
John Hays Hammond
George W. Goethals
George Westinghouse
Guglielmo Marconi
Henry Ford
Ralph Modjeski
Benjamin G. Lamme
Michael Pupin
John R. Freeman
Clemens Herschel
Gustav Lindenthal

HENRY MARTYN MACKAY

Henry Martyn Mackay, dean of the faculty of applied science and William Scott professor of civil engineering at McGill University, died October 25, in his 63d year.

His loss is regretted by the engineering profession of the continent, having been associated as consulting engineer on many major projects of United States, Mexico and Canada, including the building of the new Harbor Bridge.

Dean Mackay early showed promise of the successful career which he was to attain in the engineering and educational worlds. He was born at Plainfield in Pictou County, N. S., in 1868. His early education was gained at Pictou Academy, following which he entered Dalhousie University, graduating in 1888 with the degree of Bachelor of Arts and honors in pure and applied mathematics.

A period in practical engineering and educational spheres followed. After graduation he was attached to the Department of Marine at Ottawa. He started his teaching career at Pictou Academy in 1889, later entering McGill University where he graduated in 1894 with the Bachelor of Science degree, with honors and the Governor General's medal for the highest standing in his year.

Subsequent to his graduation from McGill, he became principal assistant to Dr. W. Bell Dawson, who was then inaugurating a survey of tides and currents in Canadian waters. Later he became associated with the firm of Waddell and Hedrick, consulting engineers of Kansas City, and was engaged in the design and construction of bridges and other structures. During this period he was for a time in charge of the work of the firm in Mexico and superintended the construction of more than 100 bridges, including some of the biggest in that country.

In 1904 he was invited to join the teaching staff at McGill. Rapid promotion was accorded the new member of the staff, Dean Mackay successively being lecturer, assistant professor, associate professor until in 1908 he was appointed a full professor of civil engineering. Appointment as dean of the faculty came in 1924 upon the retirement of Dr. F. D. Adams.

DATES OF SECTION AND BRANCH MEETINGS

We are printing herewith a portion of a letter received from a member. The information he seeks would be of value to many institutions. Will you please send the Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa., the dates of your branch or section meetings so that this service may become a regular part of the JOURNAL OF ENGINEERING EDUCATION?

I wish you would list the forthcoming meetings of the Society for the year 1930–31. The question was asked at our last department meeting and I could not answer it. Incidentally and in that connection, would it not be very desirable to print in each issue of the JOURNAL a list of meeting dates whether of the Society as a whole or of the Sections and Branches? I have often looked through a JOURNAL in vain to find such a date. One side of one of the fly leaves could very appropriately be used for such a purpose, continued as a regular feature.

SECTIONS AND BRANCHES

The program for the October 14th meeting of the Purdue Branch of the S. P. E. E. was as follows:

Report of the Montreal Meeting—Prof. C. F. Harding
Report of the Summer School for Teachers of Drawing and Descriptive Geometry—Prof. J. Rising
Report of the Summer School for Teachers of Civil Engineering—Prof. W. E. Howland
Some Aspects of Engineering Education in the Orient—Prof. W. K. Hatt

In the election of officers which followed the program the following were names for the year 1930–1931:
President—J. D. Hoffman, Professor of Practical Mechanics.
Secretary—S. Fairman, Assistant Professor of Applied Mechanics.

TWENTY-THIRD ENGINEERS

Four thousand, eight hundred and eighty men lived together as members of one regiment for twenty months. THE TWENTY-THIRD ENGINEERS was the second largest organization of the World War, and had in it many highly trained specialists.

Most of these men have not seen each other since 1919, as their homes are in every state in the Union. Now, however, a reunion

on a large scale is being planned. To make it succeed we need the correct addresses of all former members of the regiment.

Probably some of these men read your magazine. If you feel it would be proper to do so we would greatly appreciate having you suggest in an early issue that all of our former comrades send their name and correct address to Doane Eaton, 50 Morningside Drive, New York, N. Y.

Return to the Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

Society for the Promotion of Engineering Education

Date........................

THE UNDERSIGNED desiring to become a member of

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

hereby agrees to conform to the requirements of membership, if elected and submits the following:

STATEMENT OF QUALIFICATIONS

Full Christian Name and Surname.......................................
Print Last Name First Middle

Mailing Address (Number and Street).................................

Post Office (City and State)...

Full Title of Professional Position...................................
(Title) (Department)

Full Name of Institution..

(To be Signed by Two Sponsors)

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BOOK REVIEWS

Textbook of the Materials of Engineering. By HERBERT F. MOORE, Research Professor of Engineering Materials, University of Illinois. New Fourth Edition, xiv, 384 pp. of text, 14 pp. of Questions, 11 pp. of Index. Price, $4. Published by McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York. 1930.

This is a "thorough revision of a standard (elementary) treatment of the physical properties of the common materials used in structures and machines and includes brief descriptions of their manufacture and fabrication." The chapter on failure has been expanded into three chapters, on elastic failure, failure by creep, and failure by fracture. (The term "elastic failure" is not a happy one.) There is a new chapter on the crystalline structure of metals by Professor J. O. Draffin. A similar chapter on non-ferrous metals and alloys would be particularly useful and to be desired in future editions. The same may be said of the chapter on "Concrete" by Mr. H. F. Gonnerman. The chapter on specifications has been entirely rewritten and has been supplemented by much material taken from the "Standards of the American Society for Testing Materials."

As an elementary textbook, it is intended for use concurrent with the study of the Mechanics of Materials, rather than as a preliminary study to the latter and subsequent to the study of mechanics as covered in courses in physics. The chief objection to the book is that it tries to cover too many subjects. "Timber" is treated very well in the space devoted to it, but the two pages taken from the "U. S. Forest Products Laboratory Notes on Working Stresses" might well have been reserved for a more advanced course and text on Design, or for reference. The same is true of much of the Mechanics of Materials, as it may have the effect of discouraging the student who has not yet had sufficient training to relate the mechanics to the materials under consideration.

It is always questionable whether several (28) pages should be quoted in a textbook from such a publication as "Selected A. S. T. M. Standards for Students," or that the students be referred to copies easily available for their use, or that they be advised to purchase a copy for their own library.

The most human and enjoyable portion of the book is the statement of the "Factors and Principles Involved in the Enforcement of Specifications Based upon the 1907 Presidential Address" of Dr. Charles B. Dudley, late Chief Chemist of the Pennsylvania

Railroad, and the beloved President of the A. S. T. M. It is full of meat for both the student and the young engineer, and also for others.

The book is to be commended as a text and will prove to be useful to those teachers and students of Engineering Materials who have but a little time to devote to such a variety of subjects as the metallurgy and metallography of metals, the growth, seasoning, and uses of woods, stone-cutting, stone- and brick-masonry, the manufacture and uses of cement and concrete, rubber, and numerous other materials used by the engineer, and to the commercial and economic aspects of their choice, specification, and testing.

WM. T. MAGRUDER.

Weld Design and Production. With Particular Application to Safety and Cost. By ROBERT E. KINKEAD. Ronald Press Co., New York, 1930. Pp. viii + 108. $4.00.

The welding of metals is a very old art which has, nevertheless, had but comparatively limited use. The development in recent years of oxy-acetylene and electric welding methods has caused a great growth in the use of welded joints. These newer methods are among the most modern developments in engineering construction. By thir means pieces of metal may be joined together in a manner that is oftentimes better adapted to given conditions, or more economical than riveted or other forms of joints. As a result the growth in the use of electric or oxy-acetylene welded joints in recent years has been rapid and promises to continue.

This book does not state which welding method is considered, but it apparently pertains mostly to the gas or electric process. It is stated that the book has been written "primarily for two groups: engineers who are responsible for satisfactory and safe welds, and business executives who are responsible for the cost elements of welding jobs."

The text is very general in content and might well have been expanded to considerably larger proportions. After briefly indicating some of the applications and economies of welded joints, it devotes itself most largely to a consideration of the factors effecting the safety of welded joints in steel and to emphasizing the importance and methods of control of welding procedure to insure desired results. Practically all discussion is based on welded steel joints. Nothing is said about the welding of other metals.

The actual equipment and technique for making welds is not considered. Full information is lacking regarding some of the

tests reported. The engineer responsible for welding designs and production will miss data on many important phases of the work which might well have been included in the book.

However, in spite of the brevity of the text, it contains many very good points and a valuable discussion of tests in Chapter VI. What the author has to say regarding predicting the behavior of welded joints and his consideration of the costs of failure will prove interesting and suggestive to the designing engineer. The "engineers and business executives" who have to do with welding will find the book decidedly worth reading.

A. C. JEWETT.

SUMMER SCHOOL FOR ENGINEERING TEACHERS SESSIONS OF 1931

BY H. P. HAMMOND, *Director of Summer Schools*

Excellent progress is being made in preparation for the two sessions of the Summer School to be held in 1931 which were announced in the September, 1930, number of the Journal.

The session on chemical engineering will be held at the University of Michigan beginning June 24. The party will be in residence at Ann Arbor from June 24 to July 8, inclusive, after which a trip of inspection to chemical industries, from July 9 to 14, inclusive, will be arranged for the members of the session on a voluntary basis.

The program of the chemical engineering session will be so arranged as to be of interest to teachers of allied branches, such as gas engineering and ceramics, in addition to teachers of chemical engineering. The program is divided into the following five major parts:

1. Principles of Teaching,
2. Teaching Chemical Engineering and Allied Subjects,
3. Applications of Principles of Chemical Engineering,
4. Miscellaneous, including History,
5. Recreation and Inspections.

The major portion of the program will be devoted to the second of the above divisions, and will include the aims and purposes of chemical engineering education, organization and content of curriculum, content and methods of teaching the major course in unit processes of chemical engineering, and the methods of organizing and conducting chemical engineering laboratory instruction. Divisions 1, 2 and 4 of the program will be in charge chiefly of teachers of chemical engineering and division 3 chiefly in charge of practicing chemical engineers.

The staff, as in previous sessions of the Summer School, will be recruited from among the foremost teachers, scientists and engineers of the country. It will be headed by Professor Alfred H. White, of the Department of Chemical Engineering, University of Michigan, Local Director, and Professor W. L. McCabe, Secretary.

Facilities at Ann Arbor are very satisfactory for the Summer School group. Jordan Hall, a new dormitory unit, will be available, the cost of room and meals being approximately $17 per week. Sessions of the School will be held in the east engineering building of the University.

Final details of the program are being arranged in coöperation with a committee representing the American Institute of Chemical Engineers. This organization is sponsoring the session.

The mathematics session of the Summer School will be held at the University of Minnesota from August 24 to September 5, 1931, inclusive. Dean O. M. Leland, of the College of Engineering and Architecture, is the Local Director of the session and Professor C. A. Herrick will serve as Secretary.

The program of the mathematics session includes the discussion of principles of teaching in general, the principles and methods of teaching college courses in mathematics, the presentation of certain selected phases of advanced mathematics, the applications of mathematics in science and industry, coördination of mathematics with secondary school instruction and with the professional subjects of engineering curricula, the history of mathematics and other topics.

The program of the session is being arranged in coöperation with an advisory committee representing the American Mathematical Society and the Mathematical Association of America, and, through Chairman E. R. Hedrick, with the S. P. E. E. committee on mathematics.

Further information concerning the mathematics session will be published in an early number of the Journal.

Applications to attend either session should be mailed to the Director of Summer Schools, S.P.E.E., 99 Livingston St., Brooklyn, N. Y. Such applications may take the form merely of a letter noting the name of the institution, and the academic title and teaching experience of the applicant.

PERSONAL RELATIONS OF TEACHERS *

WITH FELLOW MEMBERS OF THE FACULTY

By J. W. BARKER

Dean of Engineering, Columbia University

As General Rees has said, the relationship of one member of the faculty with all the other members of the faculty is one of the most important points in carrying out our concerted objective of developing these young men who come to us from the high schools into men who some day will become engineers. I think none of us fool ourselves into believing we are turning out engineers. Paul Lincoln said a good many years ago, that the objective of an engineering school was to turn out men who had been given such an impetus that some day they would become engineers.

In this inter-relationship between the various faculty members, there are a number of points I believe we should consider very carefully. In the first place, there is the natural point-to-point contact which arises mainly within our own departments. An educational institution is a democratic, and must be a democratic institution. That means there is no room for a single-handed autocracy. On the other hand, an institution which runs by the will of the majority alone very seldom will arrive at a concerted and definite objective. Therefore, in our work together we must delegate certain of our perogatives and certain of our work to various committees, and it is in the committee work of the faculty that I believe we most often fail.

Of course, I had a number of years' training in the army and I never can forget one of the questions which is on every army officer's annual efficiency report. It is the one question, I believe, which gives the greatest indication of the man's worth in carrying out a concerted objective. This question is asked yearly concerning each officer in the army. Superior authority having decided upon a particular objective, does he willingly and loyally coöperate to carry out that objective? I wish in many respects that same question were asked of each member of the faculty yearly. Properly constituted authority having decided upon a particular line of attack, does he willingly and loyally coöperate to carry out that line of attack?

In our committee work is the place where we determine in general the lines of attack. We must do so. Faculty meetings are too

* Presented at the 38th Annual Meeting, S. P. E. E., at Montreal, Canada, June 26–28, 1930.

large ever to lay out a concerted line of endeavor and say, "This is the direction along which we want our particular school or our particular college, or our particular university to progress." However, in that committee work I believe it is important that, until the time of the decision of the committee, there be the fullest and freest discussion. Some younger members of the faculty are appointed to these various committees, and properly so appointed, in order to bring to the committee the point of view of the younger chap, who is possibly of an age nearer that of the student, and therefore probably better reflects the student attitude, the student thought. These younger committee members hesitate very greatly to bring up before the committee their reflections upon the particular subject of discussion. Yet if a committee has been properly appointed, the reflections of each individual member in laying out the policy of the committee are very, very important. Often these younger members have for some reason failed to give their views and the committee work has suffered.

The older members of the staff have a great tendency to discuss rather casually any comments the younger members make, and yet it is just exactly those comments which bring us more closely in contact with the reaction we may reasonably expect to get from the student body. Therefore, my plea for committee work is for the fullest and freest discussion up until the time any question of policy is put to a vote. After that, my second plea is for practically a unanimous vote. A committee that leaves a meeting having decided upon a line of attack on a particular problem, divided against itself, with certain members after they have voted on the subject talking against it, is almost impotent.

Therefore, in the department or faculty committee work I want to leave two points of view as my own idea with you. First, the fullest and freest discussion, both pro and con, on every point that comes before the committee. Second, after the committee has taken its vote, that the committee go out of the room unanimous in favor of the particular line of attack which has been decided by majority vote.

Faculty meetings are very much the same way. Our committees report to the faculty. Again, unless the committee acts with power for the faculty, there should be the fullest and freest discussion of this committee's report. Then the faculty itself, after having acted upon it in its due judgment, should lay aside any personal opinion as to the right or wrong, good or bad of the particular point of view, and act unanimously in loyally coöperating to carry out the majority decision of the faculty. We have all experienced times in committee meetings and faculty meetings when this has not been the case. The committee has made a decision, they come

in, go to the faculty meeting, and nearly half of the members of the committee will argue in the faculty meeting against the report of their own committee. While that may sound as if I were arguing for the autocracy of the committee, I am not. I simply believe that no committee should report out a matter of major importance until it can have argued itself into the frame of mind where it is practically unanimous.

So much for the committee work and the faculty work.

Another of the things which I believe is of the greatest importance is our own social life, one with the other. I have seen more points of major importance to the university settled outside of the faculty room over the tea table, or in the smoking room, and settled satisfactorily, than I have ever seen settled in committee. Only too frequently you take a committee with very divergent opinions out of the committee room and feed them a little coffee or tea, and sit down and smoke, and you can bring them around until they are all unanimous in favor of a particular line of attack. By that I do not mean that there is no necessity for give and take. Necessarily there must be such, but the give and take is more easily expressed I think over a tea cup than it is in a formal faculty meeting or in a formal committee meeting. So that the next part of my plea is for the importance of maintaining our personal relationships on the friendliest of planes.

It seems to me there are three important effects which come from this increase in the social life of the faculty. First is the broadening effect. We have all heard a great deal of talk about it. The engineer has been accused of being narrow. Personally, I do not agree with that point of view for one moment, but it may be so. Certainly if it is so, the more contact we have with our arts friends outside of the classroom and outside of the committee room, and outside of formal faculty meetings, the more broadened we will be; and if the reverse of the case is so, that the engineer is the broader chap, then so much the better for the arts chap to come in contact with him outside of the faculty. Therefore, I make this plea for a broader social life from the point of view that it does exert a broadening effect upon each individual member of the faculty and their wives who come in contact with them, because the ladies exert a very potent effect in every faculty, as you well know.

There is a second point which this social life brings up. We all of us think our own particular subject is of the greatest importance. I wouldn't for one moment detract from that point of view. Yet with everyone of us thinking our own subject is of the greatest importance, certainly there ought to be some interesting informal discussions about the relative importance of things. The point I wish to bring up is if we stay tied down to our particular

subject we will tend to develop an ingrowing disposition, and there is no finer way I know of to eliminate an ingrowing disposition than to argue for the importance of our own particular subject with some other member of some other college or faculty of the university. So that the development of our social life will tend to prevent our ingrowing dispositions.

Furthermore it will tend to prevent our developing a superiority complex. That word has been very heavily overused in the last few years, but it is the only one of which I can think at the present moment that expresses what I have in mind. We are all dealing for at least nine months of the year with immature minds, growing minds. We stand up before them and we often must deliver the laws of the "Medes and Persians" to them in our discussions. We inevitably tend to develop this so-called superiority complex, and yet by this social life, this intercourse between the various staffs of the college, of the engineering college, and between the various colleges of the university, we can work ourselves out of that superiority complex to the point where we appreciate very fully that each other man has a very important point of view to which it will pay us well to listen and from which to take pointers.

Thirdly, on the social point, we have to consider the situation which is arising and has arisen in all of the various engineering colleges. Much has been said about the raiding of the college faculties by industry. Much has been said about the underpayment of the faculties, with which of course I will take no issue. But I believe that by building up this social life among ourselves we can make university life so very attractive to us all that it will take a very potent influence to make us withdraw from our pleasant social intercourse, one with the other, to leave and go into industry or into some other work, of whatever description it may be.

So that in summing up the importance of this social side of the point of view, I want to bring out again these three things: the broadening effect one upon the other, the overcoming of this superiority complex, and the fostering of the morale of our staff.

Now there are a number of methods available, and I am one of the greatest believers in the so-called faculty club. A place where the faculty can meet socially, to lay aside completely the cares of the classroom, the cares of the office, and have luncheon together, discuss these various points of view informally, where we can have special lectures by visiting prominent personalities, where we can have our evening affairs, where there can be a residence for the bachelor members of the staff—it seems to me that such a faculty club can be of the greatest influence in molding our staffs and our faculty into one unanimous whole, a family of friends that works and lives and acts together to develop and bring out the best in

these young men who are delivered to us, and to make our particular school of great influence in the country today in fostering proper engineering education.

WITH STUDENTS

BY CHARLES L. KINSLOE

Head, Dept. of Electrical Engineering, Pennsylvania State College

Closer personal contacts between teachers and undergraduate students in engineering colleges; how these contacts may be secured; and the best use to make of these contacts when they may occur are problems which are receiving more thoughtful attention now than at any time in the recent history of technical education. Constantly there is an increase of evidence to strengthen the belief that in spite of the many defects and weaknesses of the purely technical training of the engineering graduate, his most serious deficiencies are not those due to inadequate preparation in the subject matter of his curriculum. Failure of the young engineer to make satisfactory progress during the years immediately following his graduation usually may not be attributed to insufficient mastery of those subjects which are generally considered to be the fundamentals of his formal education. The leading engineering colleges, by constantly raising academic standards, limiting enrollments, strengthening teaching personnels, and improving methods of instruction, have done much to eliminate from graduating classes those men whose limited capacities and technical abilities would seem to disqualify them for successful participation in one or more of the diverse activities in the field of engineering.

With the realization of the fact that many of the ablest of the young engineers do not quickly develop qualities necessary for industrial leadership came insistence that engineering curricula be "broadened," "liberalized," "humanized." Increased formal instruction in one or more non-technical fields has been urged as a means of socializing the engineer and doubtless a limited compliance with this demand has been beneficial.

Perhaps the time has come when engineering colleges as well as industry must take a much more comprehensive and far reaching view of the whole complex and tremendously important problem. Conceivably they both need to realize that notwithstanding serious difficulties, physical as well as economic, which at present bar the way, the problem must be faced and correctly solved for there is no escape from the fact that the industrial life and the national life of the future vitally depend upon the trained leadership which must be drawn in very large measure from our engineering colleges of today.

The satisfactory solution of the problem is not to be found in any recasting of the content matter of engineering curricula, in the improvement of formal lecture room or laboratory instruction, in the accumulation of more elaborate and more costly equipments, nor in more highly organized or specialized "training periods" conducted by industry, although all of these are highly important. Fundamentally and essentially the problem is one of human relations and human contacts. It is concerned with the family relationships, the preparatory school days, the years in college and with the subsequent introduction into industrial life.

This paper attempts to deal briefly with only those personal relationships which exist, or which should exist, between the engineering student and his teacher.

If it be assumed that the college has taken all steps possible to provide the ablest teaching staff available and has selected its students with the utmost care, what can be done to assure the greatest and most worthwhile benefits from the association of these two essential groups during the four years in college? Are the present class room and office contacts the only ones that are practicable or desirable? To what extent should the influence of the teacher affect the life of the student? How may a closer association of teacher and student be secured?

For intimate relations obviously the small college, located in the typical "college town" has a distinct advantage not enjoyed by most of the more important technical institutions with their customary large undergraduate enrollments frequently coupled with a location in a metropolitan area. Generally, teaching schedules in the technical schools are heavier than those in the Arts colleges. There is constant pressure to increase the amount of graduate instruction offered and there is a natural and wholly commendable urge to participate to a greater degree in research. Too frequently all this has resulted in delegating in growing measure to graduate students and teaching assistants instructional duties for which their meagre training and lack of professional experience have not as yet properly prepared them.

Interesting projects lately have been announced by some of the largest universities which, when completed, should greatly assist in lessening difficulties due to city location and to large enrollments. Among these are the proposed new housing plans of Harvard and Yale universities and the recent decision of the trustees of the University of Pennsylvania to remove certain undergraduate departments to an entirely new suburban location at Valley Forge.

It may be of interest briefly to describe a few methods successfully employed by the Department of Electrical Engineering of

The Pennsylvania State College to make possible and encourage closer personal relations between the older and more experienced members of its teaching staff and the students coming under their direction. The instructional organization of the department consists of fifteen men holding professorial rank or that of instructor and all are on a full time basis. Every member of the staff has had considerable teaching as well as industrial experience. Each year there are enrolled in the department from four hundred and twenty-five to four hundred and fifty undergraduate students and in addition, some instruction is given by the same staff to about two hundred non-electrical engineering students. An average senior class is composed of eighty to ninety men and a typical freshman class is made up of about one hundred and thirty-five students.

Following the practice of the school of engineering of which the department is a division, each enrolled student is assigned to a member of the teaching staff who acts as the student's "Adviser." The Adviser is responsible for all matters pertaining to the student's schedule; he recommends and executes any necessary faculty actions and, in short, has complete supervision of the student's academic life. But of much greater importance is the fact that the Adviser has the opportunity of knowing his students personally and intimately. He may inform himself as to their living conditions, student associations, outside activities, their health and attitude of mind. At the same time the student soon acquires a degree of familiarity and friendliness with the Adviser which he seldom feels for the teacher whom he meets only in the lecture room. The Advisers are changed at the beginning of each college year so that at the time of graduation these contacts have been established between each student and four members of the staff.

Further intimate relationships between teachers and students are secured by means of an orientation course given during the second semester of the freshman year and continued through the first semester of the sophomore year. For this course students are divided into sections of fifteen men each. They meet in a specially designed and equipped laboratory for one three-hour period each week with some one of the older staff members. They undertake the solution of simple engineering problems, the data for which are secured by the students from comprehensive equipments illustrating electrical applications in diverse engineering fields. Informal talks and conferences, not only with the instructor in charge, but with other staff members as well, afford an excellent opportunity to give to the student a better engineering perspective and, also, an opportunity to discuss, somewhat leisurely, many personal problems of vital concern to the student.

Laboratory instruction, because of the character of the work and the longer periods involved, offers possibilities for more intimate association. Consequently, in the general laboratory courses, classes are divided into sections of fifteen men each and these sections are subdivided into working groups of three men each. Each student in turn serves as leader of his group and, while so serving, is directly responsible to the instructor for planning and conducting the work undertaken. This plan not only increases the student's sense of responsibility but, during each three-hour period, a group of five students is constantly cooperating with and assisting the experienced teacher in charge. The special laboratories, such as those devoted to communications, transmission, traction, and illumination, because the numbers involved are much smaller, afford even more favorable opportunity for much less standardized procedure and in them practically individual instruction becomes possible.

For the past six years many members of the senior class, who have shown marked interest and ability in one or more lines, have been afforded an opportunity to devote about one-fifth of the time of the final year to special work directed by the ablest teachers on the department staff and credit toward a degree is given for all work so done. Usually three or four students work with the same teacher on problems of common interest. The method employed is a combination of seminars and personal conferences. Invariably the work is of high order and arouses great interest in the students. At present this opportunity can be offered to about half of the seniors and the results have been exceedingly satisfactory.

During the college year 1929–30 a most interesting and promising experiment in engineering education was conducted by the department of electrical engineering with the cooperation of four great electrical industries: The American Telephone and Telegraph Company (and associated companies), The General Electric Company, The Westinghouse Electric and Manufacturing Company, and The West Penn Power Company. This experiment was quite fully described in a report submitted by Mr. R. E. Doherty at the eleventh Industrial Conference held at The Pennsylvania State College in May, 1930, and which shortly will be published in the Proceedings of that conference.

Fifteen outstanding seniors in electrical engineering and in electrochemical engineering were selected for a course of seminars continuing through the entire first semester. The course dealt with the functional organization of industry and each of the four supporting corporations assumed responsibility for the work of one month. During three weeks of each monthly period the students met about a conference table with major executives, engineers,

scientists, and commercial men selected from the particular industry in charge and during the remaining week of each month additional meetings were held with a member of the department staff. Thus the idea of personal contact was extended to include the industrial leader who, for a brief period, became the student's teacher and counsellor. The benefits to the students were very real and the plan, in a somewhat modified form, is to be continued during the next college year.

All of these plans are but imperfect attempts to supplement the older and more generally accepted methods of engineering education with something a little less standardized than that which has heretofore prevailed. They are first steps in an effort to deviate somewhat from the practice of dealing with engineering students en masse toward a more individualized form of instruction. It will be noted, too, that every move in the direction of instruction planned for the individual inevitably means an increased opportunity for closer personal relations.

Constantly we are reminded by those at the very pinnacle of present-day industrial leadership of the vital need of a new type of leadership for the future. For the creation of most of the problems and complexities, both economic and social, the scientist and the engineer are held responsible. Willingly or otherwise they are to be called upon, in increasing numbers, to participate in the *solution* of these problems. Research, discovery, invention, and industrial development are not to stand still. To carry on all of these activities, more and more technical men will be required. But in addition, to this new and different leadership, industrial and political, engineering must make a liberal contribution and, in very large measure, this contribution must come from the engineering colleges.

All of this requires the best technical training it may be possible to give but it demands infinitely more. It means that to our engineering colleges must come in greater numbers a type of student now frequently attracted to other fields—the boy with the intellectual ability required by the rigor of the engineering curriculum and who is also possessed of a keen interest in his fellow man. It means that our engineering faculties must extend their own horizons to include this broader professional perspective. It means that some way must be found to span the distance between the engineering student and his teacher.

WITH THE COMMUNITY

By BRIG.-GENERAL C. H. MITCHELL

Dean, Faculty of Applied Science, University of Toronto

The relation of a teacher to his university environment and the surrounding community is to-day no small measure of his usefulness. In the old days a university professor led a species of monastic life; he was concerned only with an academic life and his chief aim was to instruct only those who cared to come and sit at his feet. To-day it is different. Those times have long passed and, with the radiation of knowledge and learning from a university centre which is the present-day tendency, the real teacher fulfills his greater mission when he carries his influence to successive zones far beyond the walls of his university. It might not be going too far afield to remind ourselves of the striking slogan of an historic revivalist who embarked on his religious movement by saying "The world is my parish."

Let us, in considering this phase of university life and work, go back to first principles. Let us go back to those principles which underlie the young man's desire to acquire a university education. Whether he does so from the ambition to secure an education for its own sake—or rather for his own sake, or whether it is simply to place himself in a favorable position to gain a livelihood, it matters little. The fact is that he acquires the education by the combination of efforts primarily put forward by himself but secondarily by his parents, perhaps, and certainly by the community which places a university at his disposal at which to pursue his ambition. The contribution of the community in this sense may be either by means of a state university or an institution endowed from private sources. However it may be, it is provided for the student by his fellow citizens and he takes advantage of it.

This being so, is it not reasonable that the conscientious student should realize that he owes something to the community which has made his education possible? Is it not reasonable that he should seek some means, at some time in his career, by which he can discharge this obligation in some form? I am one of those who believe that all university graduates owe it as a duty to the community or the state to return to it something in the form of service which he can offer from time to time as he progresses in his career.

If this principle applies to the university graduate himself, is it not reasonable and logical that it can apply also to those who teach the graduate, themselves graduates like him but of an earlier decade? It might be said that teachers—whether senior professors or junior instructors—are already discharging, or have already discharged, any such obligation they may owe to the state or com-

munity by offering themselves for the profession of teaching. To such critics there is nothing more to be said. Those who are in the profession know from their own consciousness the extent and value of their rewards and realize the pleasure they derive from their profession.

The idea which underlies this broad principle, in so far as it can apply to the university professor is, in my opinion, that when he chooses that career, he weds the university and lives with it. Its interests become his interests. He helps adorn his home, he improves and beautifies his surroundings, he helps his neighbours and he enters into the social life of his neighbourhood. All this is natural in our everyday life. Why not apply it to our university life?

And what do these neighbours of the University expect? What is reasonable for them to expect of the university professor who goes in and out among them? The community may not realize that it expects anything, it may not know what it wants in the way of service and help. But it does know that the professor is an educated man, he is a person who knows a great deal more about his own subject and taken as a whole, all the professors of a university—a summation of them collectively—know vastly more than any coördinated collection of the members of the community. If, then, the community thinks about it at all—and all communities think in some form or other—it is only reasonable that it will expect its university neighbours to be neighbourly, to be friendly, to be helpful and even generous.

True neighbourliness must be reciprocal. It is not sufficient that neighbours simply meet on the streets, or in the shops, or in the markets and "pass the time of day" with each other. It must be a friendly intercourse in order to be genuinely neighbourly. Good neighbours, however, do not need to live on each others door steps or be unduly intimate, nor need they run in and out of each other's houses without knocking.

If the members of the university household visit freely with those of the community household, there can be a genuine helpful coöperation. They can even lend each other many things as good neighbours do—spades, brooms, dusters, grass cutters, and even food—for thought. And it surely can work equally both ways.

If the members of the community household are not sometimes asked to come and visit at the university—the big house on the hill—how can they appreciate how the university household lives and occupies its time. Looking at its windows and doors from a distance and watching its occupants coming and going is not good enough. There is an altogether different sense of friendliness and neighbourliness when the community—down town—can say, "Oh

yes, we have often been up there, we like to go, they are so friendly and hospitable."

On the other side of the picture let us visualize the university professor visiting and mingling with the community household, down in the city, "below College Street." Surely he is welcome. The city community is glad to see him. He adds to their sociability, to their widened interest in life and to their store of knowledge. He helps them with their problems and their work. Whether it be at the Parliament or State Buildings, at the City Hall, at the Chamber of Commerce, or in a Club corner; whether at the Stock Exchange, the Banks, the Art Gallery or the Museums, in the Music Hall, or in the lecture hall of the large hotel, or whether it is in the Church, the Hospital or the Neighbourhood Settlement, it is all the same. The university professor can be a very helpful neighbour and he who has done it knows how much it widens his own horizon and his university usefulness.

The ever widening usefulness and influence of the university is a sign of the changing times. The immediate university circle as it was several decades ago, is not enough, is not wide enough. Surrounding all universities there are organizations, not a part of the university proper but a definite part of university life and influence. In these there is much opportunity to exert effort and employ talent which a university gathers about it. Some members are more adapted to one and some to another form of activity but all can be useful in these contacts in the zone which immediately surrounds the university.

There are outer zones, wider and more far reaching. Some are concentric, some perhaps eccentric. Some are merely in contact and some are quite detached. All circles or zones, however, in whatever form they arrange themselves, show the character and breadth of the university influence, ever changing, widening or re-forming though they be. The pattern may prove to be the distinctive design by which the university is known and has gained its fame.

Let us, in imagination, draw a diagram—it may look like the solar system and why should it not be similar? The university can shed its light and warmth to a wide expanse in our modern civilization.

We can draw the diagram in circles, in ovals, in ellipses, even in parabolas and hyperbolas, so long as there is some centre, some focus or some origin which is the university itself. We may even make our diagram in the colours of the spectrum, each denoting some characteristic which a member of the university can bring to some useful field or contribute to the pattern which is the spread-

ing decoration of the university in the community or in the country in which it is set.

If, then, the members of the university staff would enter into the fullness of this widespread vector diagram with its resultants, they will assuredly get their own rewards in the service which they can offer "Pro utilitate hominum." They will gain golden opinions from their fellow citizens, for a high encomium is paid to a university professor when it can be said of him "Below College Street he is a real citizen."

WITH INDUSTRY

By R. E. DOHERTY

Consulting Engineer, General Electric Company

The phase of this general subject which I have been asked to discuss is the teacher's relations with industry. It is generally acknowledged that some form of contact between the engineering teacher and industry is extremely desirable, if not essential, to effective educational work in engineering. The advantages are numerous. In the first place he is thrown in personal contact with practicing engineers who are doing the kind of work which many of his students will one day be doing. Knowing such engineers and their professional activities, he is better able to bring their point of view to the class room, and more appropriately to adjust his own. Secondly, he is able to pick up during such association in industry, engineering knowledge which will be helpful in his educational work. The extent of this, of course, depends somewhat upon the character of the work he does in industry. Another very important advantage, even if it is of a more or less intangible character, is that he becomes acquainted with the general atmosphere in the industry. He is thus in better position to answer students' questions in this connection. Although there are other values in such contacts, the foregoing are, in my opinion, by far the most important.

These contacts have a number of different forms. One important plan is the S. P. E. E. Summer School for engineering teachers which has been held during the past few summers in the immediate neighborhood of an industrial center, thus making it possible for the enrolled teachers to establish contact with industry during the session. It is my understanding that these meetings have afforded a real opportunity for the teachers to become acquainted with certain important phases of industry.

Perhaps more important still from this particular point of view are the Summer Conferences for Professors which some of the industries have held. These conferences have great possibili-

ties in providing engineering teachers with precisely the contacts and information which they regard as of most value in their college work, because that is the objective around which the conference programs are framed. The professors have the opportunity to discuss among themselves and with engineers and executives in industry the problems which they face in their teaching work. These programs, in other words, are different from most of the other forms of contacts referred to in that they are organized for the specific purpose of giving the members as much information and as thorough acquaintance with industry as it is feasible to crowd into the time allotted, whereas the other contacts have some other general purpose, with the objectives here under consideration as of perhaps secondary importance.

Another form of contact is employment during summer vacation, or for a longer period during sabbatical leave. In these, especially in the latter, the teacher takes up some regular engineering work, and, for the time being, becomes a regular employee. Although he may thus miss some of the broader aspects of the activities in industry with which members of a Professors' Conference become acquainted, he nevertheless becomes more thoroughly acquainted than they with some special phase of engineering. Naturally he also becomes much better acquainted with fewer individuals. In other words, working as an employee, the scope of both his activities and contacts is relatively more specialized, yet, at the same time, more thorough.

Still another rather special form of contact is the association with industry from time to time in connection with engineering or research problems, toward which he may be in position to make a contribution. A reasonable number of such contacts seem to me highly desirable both from the point of view of the teacher and industry, provided two essentials are recognized. One is that, from the point of view of the educational institution, the time and effort expended upon such work should not interfere with the efficiency of the teacher's educational work. The other, from the point of view of industry, is that the professor's contributions to the solution of such problems should justify the arrangement. Where these conditions are met, such practical contacts would seem to be helpful to the teacher in his educational work also.

Turning now more specifically to the activities along these lines as conducted by the industrial concern with which I am associated, the following table indicates the extent to which this organization has participated in such programs during the last three years.

Summer	Engineering Depts. and Test	Research Laboratory	Professors' Conference	Total
1927.........	14	3	23	40
1928.........	16	6	25	47
1929.........	24	14	24	62

I think it is in order to mention one problem which is encountered in the administration of these activities. The number of applicants for the Professors' Conference and for summer employment, etc., exceeds very greatly the number of opportunities which are available. It is thus a difficult matter to determine to whom the available opportunities will be accorded. Naturally, in the case of the Professors' Conference, it is attempted to have, in any particular year, as wide a representation from different institutions as possible; and then, over a period of years, to include all of the technical colleges.

As to positions during summer vacation or during sabbatical leave, these are determined in individual cases upon the basis of available openings at the time along the particular lines in which the teacher may be interested. Thus the character of engineering assignments in this connection varies over a very broad range.

In addition, I should like to mention one plan which may be of interest. In conducting the Advanced Course in Engineering (which comprises post-graduate training of an advanced character to a highly selected group, extending over a period of two or three years) we need competent assistance. We have found that, in addition to the engineers who are regularly occupied in carrying on this work, it has been of great value to us to have one or two professors assist us, who are on sabbatical leave. In this arrangement they spend part time on the Advanced Course work, and the remainder on some development engineering in coöperation with some one of our leading engineers. From our point of view this has been highly satisfactory in that we are given the benefit of the teachers' advice and experience in educational work; and the professors who have participated in this program have assured us that it has been very valuable experience for them.

From all of the foregoing, it is clear that Industry is recognizing the desirability of affording engineering teachers the opportunity to become familiar with the industrial atmosphere, acquainted with practicing engineers, and to acquire engineering information which may be helpful in their teaching work.

THE RESPONSIBILITY OF THE ENGINEERING TEACHER *

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A famous preacher was once asked why he always began his sermon with a text. He replied that he had found it a good plan to give his audience at least one thing worth remembering. Accordingly, let us take a text. In the *Educational Record* for April, 1928, a committee of distinguished educators named by the American Council on Education to consider the problem of enlistment and training of teachers raised the question "What does a college teacher do?" A tentative answer was formulated under thirteen heads as follows:

1. Masters the subject to be taught.
2. Organizes the content in proper perspective.
3. Adjusts it to the college and the curriculum.
4. Studies the needs, capacities, interests and aspirations of the students.
5. Defines the specific values they should get from the work.
6. Inspires them to want to get the values intended.
7. Appraises student achievement and compares results with those of others.
8. Weighs the evidence and improves instruction.
9. Coöperates with colleagues in maintaining morale and in administration.
10. Discovers significant relationships among thoughts and things.
11. Develops a coherent vision of progress.
12. Creates tools that make realization of the vision possible.
13. Etc., Etc.

A text may be likened unto a gate; one may swing on it or he may pass through it. Most of the program of this school can be classified somewhere under the first nine of the above heads. The speaker, it might seem, was expected to enlarge upon the last four, with special emphasis, perhaps, on the item "Etc., etc."

Teachers of drawing have had an important place in engineering education from its beginning. The first engineering school

* Condensed Version of a lecture delivered at the Engineering Drawing and Descriptive Geometry Session of the Summer School for Engineering Teachers, Carnegie Institute of Technology, Pittsburgh, June 19, 1930.

was organized in the office of Perronnet, chief engineer of bridges and highways under Louis XV of France, in order to assure the training of a corps of engineers, designers and inspectors who could work together under common norms and conventions. The presiding genius of the Ecole Polytechnique of Paris—an institution that has left its mark on every engineering school in every land—was Gaspard Monge, the inventor of Descriptive Geometry. Gen. Thayer brought the influence of Ecole Polytechnique to West Point in 1817 and Prof. Greene to Rensselaer in 1846, and from these two sources it has radiated to all our engineering colleges. The older a usage, the less likely it is to be called into question. Descriptive geometry has held its place in the engineering curriculum for a century and a half, and while it has yielded time for other purposes, under the constant pressure of an expanding scheme of studies, there has been remarkably little questioning of its grounds for inclusion. Engineering educators have been disposed to grant its claims to value as a rigorous intellectual exercise, as a means of developing and organizing the student's powers of visualization, and as a discipline in precise representation of spatial relations. Language and ideas have very intimate relations; grammar is more than a body of conventions, it is in fact the logic of language. The same principles hold for the language and ideas of space and form, and descriptive geometry has seemed to rest secure on its premises as the grammar of spatial representation.

Every one knows that the rôle of formal grammar in the teaching of verbal language has been greatly modified. Grammar still has its technical value to the specialist in language, but a good teacher now seeks to make it an instinctive background, rather than a conscious objective in all teaching for general uses. Direct and natural methods of language teaching have largely replaced the old drill, greatly to the average student's pleasure and profit. One notes a relatively faint-hearted movement in the same direction among teachers of graphics. I am not venturing to advocate such a policy. My first point, however, is to urge the responsibility of the teacher to take an actively critical attitude toward the assumed or traditional values of his subject and his methods. In candor, we must admit that the value of descriptive geometry as intellectual discipline or as training in three-dimensional visualization is highly presumptive. Of unmistakable proof we have little. We do well to remember its French origins and to allow for the traditional French penchant for abstract intellectual discipline. The road toward proof or disproof of its specific values is beset with difficulties. We do not even know whether what we call the power of visualization is a unitary or a complex psychological trait, how this

trait or traits may be differentiated, identified and measured. Most of the tests of visualization which have been suggested are strongly colored by memory or by tactual perception. Because the road to proof is difficult, it ought not to be avoided. This is especially true of a subject of comparatively finished character. Men who are pioneering in a growing branch of knowledge may be excused for a somewhat uncritical attitude toward its intrinsic values. But growth in the science of graphics is not marked. Psychologists have taken little or no initiative in the study of visualization since Galton. Initiative waits on teachers of graphics.

My second point is that teachers of graphics have a larger responsibility than they have accepted for the entire educational process as it relates to form and space. The teaching of plane and solid geometry in secondary schools is under fire, as it deserves to be. Please do not assume that I am advocating any further reduction in mathematical training in our high schools—God forbid! But so much of the conventional teaching of Euclidean logic is sterile, considered as a science of form and space, that one wonders why college teachers complain so much of the neglect of geometry rather than putting their minds to the development of some substitute of greater functional value than the traditional courses. If one of this group were to approach a professor of education having a special interest in secondary mathematics, with an offer of collaboration in this field, it is a safe guess that he would be welcomed first with incredulity, then with enthusiasm.

These suggestions point to what seems to the speaker to be one of the chief personal problems of the teacher of graphics—that of finding an adequate field of personal initiative. If you all try to write textbooks, you become like that fabulous land where all the people lived by taking in each other's washing. Your subject is not actively growing. Its research possibilities are almost wholly educational in character, such as the critical evaluation of objectives, content and methods, the measurement of aptitudes and attainments before and after taking, the effort to gain economy of time and effort in reaching certain defined objectives and the like. If these do not appeal, the teacher must turn to some collateral features of his work.

Let us consider briefly three such collateral fields—(1) the personal counselling and guidance of students; (2) teaching, research or practice in technical fields closely related to the fundamental work in graphics, such as mechanism and machine design, graphic statics and structures, etc.; and (3) the study and teaching of the aesthetics of design. All these possibilities seem highly promising to the writer. In any case, if the teacher of graphics

wishes to rise in status and salary above a routine level he must have some sphere of initiative. However we may dislike it, the fact remains that the teacher who devotes his whole effort to perfecting himself in the art of teaching a relatively finished subject faces certain real limitations. Where may he seek outlets for his powers of growth?

The teacher of graphics occupies an exceptional position relative to new students. He is the first contact point in college with the distinctly technical and professional side of the student's work. For many of them, his subject represents the first real test in the student's experience of precise, objective standards of excellence and of economy of time and effort in planning his work. I am convinced that no well organized industrial concern would expect novices coming directly from high school to make such radical readjustments in the volume, and quality of their work as we expect of our entering freshmen, with so little guidance and supervision. The typical engineering course represents from a fifth to a third more work than the typical arts course in volume. Standards as well must be more rigorous if the student is being trained to carry in his work heavy risks of life and investment than if only his own personal development is at stake. The major problem of the freshman is that of planning his work efficiently. Nearly all that we require of him could be covered in an 8-hour day under good management. Would it be better to put all our freshman work on an all-day time schedule, provide each student with a regular work place under the continuous supervision of a definite department, and devote our major effort to efficient planning and execution of work? The present plan is defended on the ground that it trains the student to work independently. I question that—does it not merely throw the student overboard on the plea of teaching him to swim? Why try to teach independence before one knows what efficient work is?

If this plan were to be adopted a *properly staffed* department of engineering drawing might be almost an ideal supervisory force for the freshman year. Each student would have a drawing desk for his headquarters. Two class sections, about fifty students in all, might occupy a room under one supervisor, who would also be their teacher of graphics. Teachers of mathematics, chemistry, English and the like would teach much as at present. Every teacher of graphics, under this plan, would need to have many of the qualifications and interests of a high class personnel man. He would need to be skillful in diagnosing causes of bad adjustment. He would need to know a good deal about the work of all other freshman departments. He should have staff assistance from a

real educational clinician, some one who could find out what is specifically wrong when an apparently bright boy is doing poorly. Given some such set-up, we might greatly reduce freshman mortality and hand on to the second year students who know how to make their work count. There would still be three years to train the student to work under his own direction.

The second suggestion—that the teacher of graphics engage in teaching, research or practice in some related technical field—explores a radically different path. If pushed to its extreme end it might tend to reduce the departmental organization for engineering drawing to little more than a framework, with much of the personnel drafted for this service on a part-time basis from other departments. The weaknesses of the plan are fairly obvious—divided interest and responsibility, expectancy of advancement in other directions and highly decentralized supervision of freshman work. On the other hand the liaison between the drawing department, viewed as a service organization, and the technical departments would become more intimate. Taking a less extreme position, many of the advantages to the teacher and college could be gained if the teacher were to give one out-department course and carry on active research or practice in that field. Still another plan would be to include in the staff of the department of drawing one or more of a not uncommon type of draftsman—not highly trained professionally, but an artist in his way—who would have much the same status as the shop instructors and teach the practical side of the subject where skill is an object of some importance.

The third suggestion for a field of initiative—the study and teaching of the esthetics of design—is meant for occasional individuals rather than groups. The time is not far distant when all engineering schools must give more positive attention to matters of taste and beauty. In a conference with a number of officials of one of the largest of our manufacturing companies, the speaker recently raised the question of beauty of form and line as a selling point for purely utilitarian machines. The response showed a surprising interest in what may be called the architecture of machines. This subject, by the way, is a regular requirement in certain continental engineering schools. There are good reasons for urging this subject on engineers, rather than going outside to engage an artist for special lectures. What engineers strive toward, a bit blindly sometimes, is functional beauty—a beauty like that of the axe handle which represents perfect adaptation to its use. This rather than decorative art is the real field of opportunity for the teacher of graphics, but some notion of critical considerations of a purely

artistic nature ought to be given to every engineering student.

The main point, to which we return, is the responsibility of every engineering teacher for having some field of initiative outside of the artistry of teaching as such. Long experience shows that without such initiative the teacher in time ceases to grow. A non-growing teacher is unable to inspire growth in others; in fact he tends to become a drag on progress.

Every engineering teacher is concerned with gaining a more adequate scale of compensation. In the present economic order men receive what is presumed to be the market value of their services. "Market value" is a loose term, especially where professional services are concerned. There are no daily quotations, no trading recorded on the "big board." A few controlling influences are commonly recognized. Such services may have a "rarity value," as in the case of a Caruso or a Houdini; or an "emergency value" as in the surgical clinic of the Mayo brothers! or a "prestige value" as in the charges of socially prominent portrait painters; or a "cost-of-preparation value" as demanded by numerous medical specialists. It is next to impossible to invest college teaching with any of these income raising qualities, especially in the more conventionalized subjects. Good teaching is taken for granted, and distinguished teaching is so rare that the scales of rewards seem scarcely to allow for its existence. If most of us are to advance, it must come through advance in the scale as a whole.

Outside of technical fields the realms of initiative to which every ambitious teacher is pointed is research. This policy, I am convinced, would be unduly narrow for an engineering college. There are at least four fields of activity collateral to teaching which we ought to recognize as of equal worth: (1) research in scientific or technical realms; (2) original contributions to engineering practice; (3) outstanding service to the engineering profession in its organized capacity; and (4) contributions to our knowledge of educational problems and their solutions which can be passed on and applied by other educators.

One of the responsibilities of every engineering teacher is to make learning inviting to his students. By this I do not mean to sugar-coat it, but to develop in the student an appetite for learning in its pure state. This end must be accomplished largely by personal influences. The student must discover in the teacher personal qualities of a highly desirable type that he will consciously or instinctively link with what the teacher is trying to give him. Unfortunately some of the most learned men are in their personal qualities poor salesmen for learning. In a real sense, the teacher is the goods in his own show window. We all know of a self-conscious culture which repels red-blooded men, but breadth of

interests, vividness of personality, alertness of mind and a keen relish in living make an instant impression on the student in favor of the type of learning a man professes. A taste for learning grows from one's sense of accomplishment. The thing every bewildered and wavering freshman needs, more than anything else, is a taste of successful achievement. An able educator once remarked that he had learned the most important lesson of his life as a teacher in a school for the feeble-minded; it was that good education consists very largely in celebrating successes. One wonders if our rigorous engineering discipline gives the student enough chances to celebrate successes. Every engineering teacher, too, has the responsibility of inculcating ideals of excellence and accuracy, to which the high school graduate of today is so often a complete alien. The battle of morale is largely won or lost in the freshman year and the teacher of graphics is in the best position as strategist, both in his contact with the student and in the objective character of that which he gives the student to do.

My final point is, confessedly, the vaguest and most idealistic of all, namely the responsibility of the engineering teacher for outguessing the future in the development of the engineering profession. If the profession is to gain in public responsibility and influence, it will be almost wholly because of the qualities of the men it enlists. The question is three-fourths settled, positively and negatively, in the secondary schools and in the freshman year in the colleges. The first real interpreter of the profession most engineering students meet is his freshman teacher in drawing. No matter how well he knows and teaches his subject, if he knows and teaches only his subject he will only half fulfil his obligations.

GETTING STUDENTS TO STAY TAUGHT *

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Students as a type, whether they are students of engineering or of any other subject, are likely to have at least one presumably deplorable attribute in common: once taught, they do not stay taught.

The study of education has concerned itself at some length with the problem of how to insure students' retention of what they have been taught. It has investigated instances in which students have learned and have remembered what they learned. It has investigated other instances—much commoner in the experience of most teachers—in which students have learned and have promptly forgotten nearly all they knew. Out of its investigations it has drawn certain generalizations which, though they do not bring to light any sure way to make students stay taught, do at least go far toward explaining why students sometimes stay taught and sometimes do not.

The generalizations in question are usually called the laws of learning. In all, there are perhaps seven or eight such laws which are recognized by prominent writers in education. I propose to discuss some of the implications of three of these laws—the three laws which are at the same time both most generally recognized and most directly concerned with the problem of getting students to stay taught. These three are ordinarily called, in the language of educational psychology, the law of readiness, the law of exercise or repetition, and the law of effect or satisfaction. Couched in thoroughly academic terms they seem, as perhaps is fitting, to carry no very direct suggestion as to what they may be good for in determining methods of teaching. Hence I shall attempt to phrase them in such a way as to indicate their bearing on the problem of getting students to stay taught. Thus presented, they may, perhaps, make possible a number of reasonably practical conclusions, not as to how teachers may secure perfect and permanent retention of all the things they teach, but at least as to how most teachers may measurably improve their chances of doing so.

The first of the three laws which is of special significance in this connection—the law of readiness—states, in effect, that ***students tend to retain what they are taught in proportion to their own feel-***

* **Summary of a discussion presented at the Civil Engineering Session of the Summer School for Engineering Teachers, Yale University, July 2, 1930.**

ing of desire to learn it, or of need for learning it, when it is first presented to them. This is substantially a statement of the thesis which was advanced in the preceding discussion of the problem of getting students to learn.* The various schemes which were there considered for awakening students' active interest in learning—development of interest in subject matter, use of extrinsic appeals of various sorts, resort to coercion—have an important bearing not merely upon the task of teaching students in the first place, but also on the problem of getting them, once taught, to stay taught. The law of readiness carries, however, certain implications which were not directly touched upon in the earlier discussion. So far as these implications concern the teacher's task in getting students to stay taught, they may perhaps be fairly stated in the form of two explicit rules.

The first rule is a negative one: *Do not expect students to retain accurately and permanently subject matter which they have seen no "sense" in mastering.*

Students do occasionally, it is true, hold fast to knowledge or habits or skills which they have mastered merely because mastery was required. There is probably more than one adult, otherwise guiltless of any recollection of the formal geometry which he studied in high school, who can recall accurately and without hesitation that "if two triangles have two sides and the included angle of one respectively equal to two sides and the included angle of the other, the triangles are congruent"—and who can recall also that the theorem used to have an unspoken supplement in his mind: "What of it!" But accurate and permanent retention in such cases as this seems to be the exception rather than the rule.

Hence from the teacher's point of view the task of getting students to stay taught involves first of all the task of getting them to see some sense in learning. How to get them to see sense in any particular item of learning is a question to which this first rule gives no direct answer. The rule does, however, offer one positive suggestion, as well as a negative one, to the teacher. If, in the case of any given group of students, the teacher cannot get the students to see sense in the learning which he is asking them to do, then at least one of three things is likely to be true. Either the subject matter in question is something which the students do not as yet actually need to learn, or it is something which they do not need to learn at all, or the teacher in question is not qualified to teach that particular item in his course. In any case (this is the suggestion which the rule implies), that subject matter would better be left untaught by that particular teacher, in favor of something against which the odds are less great that it will never be truly learned.

* JOURNAL OF ENGINEERING EDUCATION, November, 1930.

To most teachers this suggestion is inevitably a disturbing one. It reflects darkly, by implication, on much of the teaching that is now going on in our schools and liberal arts colleges. Formal mathematics for students who perceive in it merely a detested stepping-stone to college entrance; laboratory science which seems to have as its goal only so many "experiments" duly checked by the teacher; college courses in foreign language required of students to develop superficial command of a language which they expect (and often swear) never to use—these are examples of things which have so little chance of staying taught that under the circumstances they might better not be taught in the first place. Whether there are many such things in the engineering curriculum I do not know. But in the light of what seems to be true of other fields, I suspect that it would be worth the while of engineering teachers to scrutinize their own courses in terms of this negative rule implied by the first law of learning. Does each item in each engineering course represent a real need which is seen and understood by the students for whom the course is planned, or are there many items, as in other fields of teaching, which have no sense from the students' point of view? Of these latter items the teacher may well beware: except as he can get his students to see sense in them, time spent in teaching them is likely to be time largely wasted.

The second explicit rule suggested by the first law of learning is a positive one: *Teach knowledges, habits, and skills after the students first need to use them, rather than before the need arises.* This rule obviously offers more immediate help to the teacher than does the first one. Yet, like the first rule, it carries certain negative implications; so that in considering its bearing on the task of getting students to stay taught one must properly take into account at least one type of teaching which it condemns as well as certain other types of teaching which it approves.

It condemns the type of teaching in which the teacher sets himself up as the sole or chief defender of the need for learning. Knowledge acquired merely because a paternal teacher or school promises that it will bye-and-bye be useful is knowledge which has little chance of being retained. Curricula or courses or even single units of subject matter, "learned" in response to a promise of some more or less distant future value, are likely to represent impedimenta which the student sheds as rapidly and completely as he dares.

Nor is teaching based on a promise of future value made effective merely because the promise may have some foundation in truth. One may grant, for example, that students in foreign-language courses can make extensive use of a knowledge of the ele-

ments of grammar; but students in earlier English courses seldom master the subjunctive effectively merely because they have had this truth impressed upon them. One may grant also that broadly educated persons ought to have some acquaintance with the beauties of antiquity; yet few high-school students succeed better with their mastery of Latin either because they are told that Latin is beautiful or because they are reminded of the desirability of becoming educated. One may even more readily grant that students of engineering will doubtless have important use for a knowledge of solid geometry; but the demonstrative geometry taught in our high schools and required as a prerequisite by many engineering schools seems to "stick" no better on that account. In all these cases and in countless others, the mere fact that students have been told of some future need for the subject matter presented in their courses is likely to be of little weight in producing lasting retention of that subject matter.

Here again I do not know the extent to which the first law of learning may reflect on the curricula in engineering education. Technical and professional schools in general are perhaps less guilty of flagrant violations of this law than are schools and colleges of the traditional academic type. Yet even among professional schools the tendency must inevitably be strong to teach the things that the students need to learn simply on the ground that the students need to learn them, without any great deference to the students' own convictions or lack of convictions in the matter. Hence teachers of engineering, in common with teachers of other technical and professional subjects, would doubtless do well to examine their own practice with respect to the way in which they attempt to convince their students of the value of their teaching, as well as with respect to the convictions which their efforts carry.

Consistent observance of the rule that knowledges, habits, and skills should be taught *after* students first need to use them demands, however, more than simple avoidance of undesirable practices. If the rule is to be applied effectively, the teacher must take positive steps to see that his teaching and his student's recognition of the need for learning come in close succession one to the other, and that the latter comes first.

There is a certain group of thinkers in education—a group who have been responsible, among other things, for the development of some of our most "advanced" schools for young children—who propose a striking method for seeing that pupils are taught after they realize the need for learning. The method is as simple as it is striking: it consists merely in teaching nothing until the pupils themselves ask to have it taught. In one well-known school which

adheres to this method, each pupil is taught to read, for example, not at any set point in his school career, but at that particular point, no matter how early or how late it may come, at which he himself becomes so imbued with the desire to read that he positively wants to be taught how to do so. Thus some pupils acquire skill in reading at five or six years of age, while others are left contentedly unable to read a single word until, when they are twelve years old or so, they stumble upon the idea that the ability to read is actually an ability worth attaining. The school notes with pride that by the time they are fourteen or fifteen years old the chilaren who have only recently begun to read have acquired a facility in reading quite as great as that of the children who have been reading with ease and satisfaction for years.

The results which are reported from the use of this scheme of teaching illustrate, perhaps, the effectiveness of interest in producing learning. But the scheme itself represents, from at least one standpoint, a pitiful sort of arrangement. It seems to be based on the assumption that what pupils are interested in, and whether they are interested at an appointed time in the things the teacher elects to teach, are matters quite beyond the control of the teacher. It would seem to reduce the teacher's function, indeed, to little more than that of guiding pupils' efforts whenever, and in whatever direction, the pupils may providentially happen to want to put forth any efforts. It quite ignores the fact, amply demonstrated by skillful teachers everywhere, that the teacher himself may with forethought become the special providence which causes pupils to want to learn, and that the teacher thus has it very largely in his power to determine not merely *what* pupils shall want to learn but *when* they shall want to learn it.

Hence the rule that students should be taught any given item of subject matter after they first need to use that subject matter does not mean that the teacher must be a slave to immediate circumstances in the lives of his pupils. It does mean, on the contrary, that the teacher must adopt some definite plan for getting his students to need (and to see that they need) to do the things he wants them to learn to do.

How this may be accomplished may be illustrated in terms of a procedure instituted a few years ago in the Harvard Graduate School of Business Administration. The Business School found itself confronted each year with a group of entering students who were serious in their desire to become competent in business administration, but who had only the vaguest conception of the kind of preparation which adequate training for business must necessarily involve. These students wanted from the outset to find

themselves engaged in solving "practical" business problems. They objected, either openly or tacitly, to the study of the fundamental business principles—accounting, business statistics, finance, industrial management, marketing—which the School requires of all its first-year students: such principles, from their point of view, were well enough as matters of interest to the abstract scholar, but for the practical business man they got almost nowhere. After some experimentation the School has apparently succeeded in meeting the plea of these students for "practicalness." It has done so not through lectures on the future value of an understanding of business theory, still less through changing the content of its required courses, but simply through its method of introducing those courses. At the beginning of each year its first-year students are given as their initial assignment a thoroughly "practical" and at the same time exceedingly complex problem in business administration for solution. Each problem thus used is so presented as to be recognizable immediately, even to the layman, as one which is likely to occur commonly in business practice; yet each problem is also of such a nature as to be entirely baffling to anyone who lacks training in fundamental business principles. The students have this introductory problem explained to them; they are given suggestions as to the use of reference materials bearing on it; they are granted an amount of time for its solution which doubtless seems to them ample at the outset. They go to work upon it, and as a rule the harder and more intelligently they work the clearer it becomes to them that they are quite incompetent to reach a solution. Their realization of their own incompetence is increased by what happens to the tentative solutions which they may propose. At the meeting at which their reports are discussed, the instructor who has made the assignment takes pains to show just how inadequate their proposals have been. He takes pains also to show why the proposals are inadequate—to point out in specific instances the need for an understanding of fundamental business theory—accounting, business statistics, finance, industrial management, marketing—before any intelligent attack can be made upon the problem with which they have been wrestling. As a result of this introductory confusion the School has found that its students tend to undertake their study of these fundamental subjects with the same sort of avidity which they had previously shown for supposedly more "practical" problems.

In terms of education in general, and not merely training for business, the method here illustrated consists in confronting students with a situation which can be counted on to be interesting and significant from their point of view, and which demands their use

of knowledge or habits or skills which they have not thus far acquired. The method can be made effective through various other means than through the use of such problems as those employed by the Business School. Examinations of students' knowledge or ability in matters of obvious consequence to them, given before these matters have been taken up for formal study, may accomplish a similar result. Demonstrations of valuable skills by the teacher—skills in computation, in drawing, in mechanical operations of various sorts—will frequently awaken in students an ambition to possess themselves of corresponding skills. Statements or demonstrations by the teacher which disturb students' settled opinions, but which the students are unable to evaluate without further knowledge, will often lead to a search for such further knowledge far surpassing in the permanence of its effect the results of the most carefully planned formal assignment. Through any of these means the serious student may be awakened by a skillful teacher to a feeling of his own need for learning specific things (assuming always that these things truly need to be learned), at whatever point in his development may be reasonable. For the teacher of engineering subjects, as for the teacher in other fields, the use of these means may thus represent an important approach toward solution of the problem of getting his students to stay taught.

These, in general, are some of the implications of the first law of learning. These implications can be summarized, in a sense, in terms of the two rules for teaching which that law suggest: do not expect students to retain subject matter which they have seen no "sense" in mastering; teach subject matter after students first need to use it, rather than before the need arises. It is obvious, however, that rules of this sort cannot be merely mechanically applied. To present subject matter in such a way that students may see real "sense" in mastering it calls for a thorough understanding not only of subject matter and of students but of their relationship to one another. To awaken students' appreciation of their own need for specific items of subject matter demands skill in the use of a highly complicated technique. The first law of learning is only too evidently not an easy one to apply. Yet the rules which it suggests may, perhaps, serve as criteria by which good practice in teaching may be told from practice which is less likely to be good, and may thus offer a measure of guidance in getting students to stay taught.

The second of the laws which have important bearing on the present discussion is the law of exercise or repetition. The law of exercise states, in effect, that *students tend to retain what they are taught in proportion to the frequency with which they use it.* This

is a simple enough statement—to most persons doubtless almost a self-evident one. But certain students of education have sought, through controlled investigation, to explore the validity of this statement, and in the course of their investigations they have reached a number of significant conclusions which are by no means directly apparent in the bald wording of the law. These conclusions have to do in part with the process of learning, in part with the equally important process of forgetting.

People learn, apparently, according to a fairly well-defined "curve." This curve is graphically represented, in the case of a given learner who is acquiring some specific type of skill, by recording the results of regular tests of the learner's growing proficiency as the learning goes on, and plotting units-of-skill-acquired on a vertical axis against units-of-time-spent-in-learning on a horizontal axis. Curves of learning have been thus plotted for many skills and for many learners. No two such curves are exactly alike: curves differ both for the same learner in different skills and for different learners in the same skill. No single curve is ever entirely regular, moreover, since various things which are by no means clearly understood seem to exert marked effect on a learner's progress from day to day. Yet in spite of discrepancies and irregularities in detail, the general shape of all learning-curves seems to be the same. The curves almost always rise very rapidly at the beginning of the learner's attack upon something which he is learning for the first time, ascend more and more gradually as learning progresses, and become eventually almost horizontal. They suggest, that is to say, that a law of diminishing returns operates with respect to learning just as such a law seems to operate in many other fields of human activity.

People apparently forget, likewise, according to a curve. When a student has developed a given skill to a certain degree of proficiency, and then suddenly abandons all practice in the skill and ceases to make use of what he has learned, his acquired proficiency apparently begins to fall off immediately and in large amounts. But like the curve of learning, the curve of forgetting "slows up" gradually, until at length it also becomes nearly horizontal. Thus in theory, at least, while students must be expected to forget rapidly and extensively after initial practice has ceased, they may be counted on never to forget quite all they have learned—though in fact it is often exceedingly difficult to find any trace of the modicum which theoretically they must have remembered.

Considered by themselves, the typical curve of learning and the typical curve of forgetting are interesting but of no very obvious significance. When they are placed side by side, however, the importance of what they imply becomes immediately apparent.

Suppose, for example, that a teacher wishes to develop in his students a certain degree of proficiency in the use of a mathematical formula. In terms of tests which the teacher can employ, the desired degree of proficiency is represented by a score, let us say, of 80. The teacher presents the formula to his students, starts them on a type of practice which leads to increasing skill in the use of the formula, and keeps them steadily engaged in this practice until they can attain the required score. Then he allows the practice to stop, and passes on to the development of some other skill. But then also the curve of forgetting appears. Each student retains his 80 for only the briefest possible time: with practice no longer required of him, he loses his skill both quickly and (for all useful purposes) completely.

Clearly practice must not be permitted to stop. Suppose, therefore, that after a brief interval the teacher provides for further practice and brings his students again to the 80-mark before launching on some new learning. Once again they forget; and no matter how often the teacher may resume the practice, so long as he insists on their attainment only of the minimum desirable degree of skill, his students will never for any appreciable length of time hold fast to the necessary mastery of that skill.

The moral to be drawn from this example is not at first sight an encouraging one. Students are bound to forget, no matter how often they are re-taught—that would seem to be a fair conclusion. That is, indeed, one conclusion which the teacher must bear constantly in mind; but fortunately it is not the only conclusion to which observation of the curves of learning and forgetting gives point. There are certain other implications of quite equal significance which become apparent from a study not of the curves of first learning and first forgetting, but of the curves of subsequent re-learning and re-forgetting.

When a student has learned and forgotten and then begins to re-learn, the curve which marks his second progress differs from the curve of his original learning. The amount of skill which he has lost through forgetting comes, so to speak, from the upper end of his original learning-curve: it was first acquired rather gradually, as the curve of original learning began to flatten out. But in his re-learning of this lost amount of skill, the new learning-curve rises more rapidly than did the original curve for this same increment. Each succeeding curve of re-learning, moreover, rises still more rapidly than the first, so that less and less time is required after each forgetting to gain once more the skill which has been forgotten.

Each curve of re-forgetting likewise differs from the curve of original forgetting Where as the original forgetting took place

very rapidly, each succeeding forgetting is represented by a curve which descends more and more gradually. Hence, after each succeeding re-learning, a longer and longer interval will pass before the student has forgotten any given amount. With a sufficient number of re-learnings, indeed, the student's final curve of forgetting may become so gradual that he never forgets quite all of this given amount.

If, therefore, the teacher will set a standard of proficiency for his students not just at the level which they will need to keep permanently, but somewhat above that level, there is hope that a series of re-learnings to make up for the inevitable forgettings may eventually leave the students with the necessary residue of proficiency firmly established. Suppose, for example, that the teacher in the original illustration were to require his students to attain a mark not of 80 but of 90 as a measure of the proficiency gained through first learning. Suppose that he were then to check their loss through forgetting until he found that their scores had sunk to the minimum desirable 80. He might then provide for further practice—re-learning—carried far enough to restore them to the original proficiency of 90. Once more they would forget, less rapidly than at first, till they reached 80; once more he might restore them, more rapidly than at first, to the 90-mark. Thus with repeated periods of practice, occupying shorter and shorter lengths of time and occurring at increasingly greater intervals, he might eventually bring it to pass that his students remained more or less permanently above the 80-mark, though their proficiency might never, except for brief periods, be as high as 90.

It will doubtless be evident, even from this brief description of the curves of learning and forgetting, that the investigation of the second law of learning has made possible a number of conclusions which are of much significance to teachers. I shall attempt to summarize these conclusions shortly. But before doing so I should like to point out a curious phenomenon, common in elementary and secondary schools and no less common, I suspect, in engineering schools, for which these curves of learning and forgetting seem to offer a convincing explanation.

The phenomenon consists in the widespread conviction on the part of teachers at any one level of a school or school system that the teachers on the levels below them are doing reprehensibly slipshod work. The conviction that elementary schools offer miserably poor preparation for the secondary school is almost everywhere prevalent among secondary-school teachers; the conviction that high-school graduates are exceedingly ill-prepared for college work is apparently one of the fundamental tenets of most college

faculties; the conviction that beginning courses in nearly every school subject offer but meager preparation for later work in those subjects is a common source of bitter complaint on the part of teachers of all types of advanced courses. Truly education must be in bad hands if there is justice in these widespread beliefs.

But consider a specific example of the grounds for such beliefs. A boy of normal intelligence, let us say, has been promoted from the sixth grade to the seventh grade in a public school system. He has studied arithmetic in the sixth grade, and in his studying has concerned himself extensively with the elements of percentage. His efforts have been judged so successful by his sixth-grade teacher that he has been rewarded with a mark of B—not the highest mark he might have attained, but a mark distinctly above the class average of C. He comes to the seventh-grade teacher of arithmetic at the beginning of the school year; she tests him in those same elements of percentage in which his sixth-grade teacher reported that he shone. He not merely fails to attain a score which would warrant even a sixth-grade B, but judged by the score which he does attain he "seems never even to have heard of percentage!" Surely here would seem to be a case of inadequate preparation, if there ever was one; and most teachers can speak feelingly of similar cases at every level of the school system.

Perhaps, however, the trouble does not lie wholly with this boy's preparation in arithmetic. He has had a summer vacation to contend with, and pupils are prone to forget. Reconstruct his probable curves of learning and forgetting, and see what they show: a long period of first-learning all through his sixth-grade course, culminating, let us say, in a score of 80, which stands for B; then no further learning during half of June, July, August, half of September—scores descending to 50, 30, 20, 15; and when his work begins again at the end of September a score which must inevitably look as if he had indeed "never even heard of percentage." Yet this has happened not because of poor preparation in his sixth-grade work, but in spite of the best preparation his sixth-grade teacher may have been able to provide for him—simply because pupils tend to forget things which they do not use, and to forget them quickly and in wholesale amounts.

Perhaps in this illustration will be found at least part of the explanation for many teachers' suspicion that the teachers who have preceded them have done something less than their full duty. I do not maintain that there is no slipshod teaching in American schools: there is doubtless all too much teaching which falls very far short of effectiveness. But in many instances the charge that previous teachers have done ineffective work ought properly to re-

importance of satisfaction as an element in learning seems to have received much less than its proper emphasis in most plans for teaching.

How important the element of satisfaction may be is well illustrated by an experiment recently conducted by Professor E. L. Thorndike of Columbia University.* The experiment consisted in having a number of persons practice blind-folded in drawing, at the command of the experimenter, lines three inches, four inches, five inches, and six inches long. Each person subjected to the experiment drew first an extensive set of such lines—600 in all—with no indication from the experimenter as to whether he had succeeded or failed in his attempts to approximate the various lengths. The results in most cases, as might have been expected, were very far from accurate. Each subject then underwent a course of "training" in drawing such lines. Still blindfolded, he practiced the drawing under the direction of the experimenter, but after each effort he was informed that his results were either "right" or "wrong"—"right" meaning accurate within a small margin of error, and "wrong" meaning correspondingly inaccurate. Here too the results were what might have been expected: the drawers improved rapidly and to a marked degree in their efforts at approximation. But then again they were required to draw a set of 600 lines with no check whatever upon their success. And in this second test the effect of the absence of any check was a notable one. Practically all the drawers fell off very definitely from the accuracy which they had attained in the practice period, and some of them lost proficiency to such an extent that their final scores were no higher—occasionally even lower—than those which they had gained before any practice whatever had been undertaken.

Satisfaction in this instance consisted solely in the check which each subject was given upon the success of his efforts. With that check supplied, practice was indisputably effective. But with the check lacking—that is to say, with the element of satisfaction entirely absent—such further practice as was supplied by the final test seemed to have no worthwhile effects whatever.

Consider, therefore, what the law of satisfaction may mean with respect to getting students to stay taught. Like the law of readiness, to which in a sense it supplies the complement, it suggests both a positive rule and a negative one.

The positive rule is an obvious one: *Provide all possible opportunities for worthwhile and effective use of each item of knowledge, habit, or skill which students have been called upon to master.* Provide such opportunities, so far as occasion permits, by putting

* This experiment is described in detail in Thorndike, E. L., and others: *Adult Learning* (Macmillan, 1928), pp. 96–100, 291–98.

the students into "natural" situations which call for the employment of the item in question, since situations of this sort are more likely to carry satisfaction that are mere formal provisions for drill. But see to it that things learned have a chance to be used, even if that chance must often be artificially arranged.

The negative rule, in the light of Thorndike's experiment, is hardly less obvious. *Do not expect learning to result from the use or practice of knowledges, habits, or skills in which students have no gauge of their own success.* The gauge need not always come from the teacher: it may frequently take the form of some standard which the student can apply quite independently. But some direct measure of success or failure is apparently always necessary before learning can be counted on to be effective. Practice alone *does not* "make perfect"; and work done for the wastebasket—work done, that is to say, without any direct check for the student on his own achievement—is at best of questionable teaching value.

Students tend to retain what they are taught in proportion to their desire to learn it, in proportion to the frequency with which they use it, in proportion to the eventual satisfaction which they derive from its use. Teachers ought therefore to awaken their students' interest in learning, to provide for adequate practice on things to be learned, to assure opportunities for worthwhile use of what has been learned.—These two statements represent in substance the gist of the best present answer (so far as I am acquainted with that answer) to the problem of getting students to stay taught. And there is little doubt that if teachers in general were to make full use of the procedures which that answer suggests, students would retain much more than they do now of the things that they have been taught.

In setting forth that answer I have necessarily been mindful, however, of the fact that to put the suggested procedures into full effect would require radical changes in most present plans for teaching. Schools are accustomed, at present, to undertake the teaching of many things and to be satisfied with only fragmentary retention of what their students have been taught. Schools in general doubtless try to teach too much, and end by actually teaching all too little. It is not hard to see why this is so: the task of securing students' retention of what they are taught is difficult and time-consuming, no matter how effectively the laws of learning may be observed; and the pressure of "ground-to-be-covered" is so great that schools and teachers in general are unwilling or unable to give all the time and energy to each single unit of subject matter which permanent mastery of such units demands. But though the

reason for the present state of affairs may be obvious, its obviousness does not lessen the difficulties which confront any teacher who tries to go beyond a mere covering-of-ground. Hence I should like to make at least a brief attempt, in concluding this discussion, to show how the suggested procedures may be successfully applied.

If under present conditions any single teacher is to teach any large part of his subject matter in such a way that his students do actually stay taught with respect to it, he must take advantage of all possible economies in learning. He must find some method, in other words, for saving time ordinarily devoted to less important matters in order to have more time to give to the task of insuring his students' permanent retention of essentials.

Such saving of time is entirely possible in much of our present teaching. Three major economies alone would add greatly to the opportunity of which most teachers can avail themselves for teaching essential things permanently. One such economy is to be found in teaching nothing which will have later to be untaught. If, for example, students must eventually perform mathematical calculations according to a given technique, then in the long run time may be saved by requiring them to practice that technique from the outset, even though a different technique is easier to teach at the beginning. A second economy may be secured by avoiding insistence on detailed mastery where possession of a usable "idea" will suffice. To bring oneself to the point at which one can understand and retain the gist of a chapter in a textbook is, for instance, less difficult and less time-consuming than to commit to memory every point included in that chapter; and the "general idea" in such a case may be quite as effective as memory of itemized details. The third economy consists in requiring mastery only in matters in which mastery is actually essential. It is almost a truism that schools seek at present to have their students master many things of which mastery can be expected to serve no good purpose. Why, for example, should students be required to distinguish three different classes of levers when thorough understanding of the single underlying principle of levers will enable them to deal adequately with any lever, no matter what class it may represent? or why should students learn one rule for finding the square of the sum of two algebraic terms and another rule for finding the square of the difference of two algebraic terms when a single rule for squaring a binominal, quite as easily taught, will completely cover both sum and difference? Through teaching nothing which will have later to be untaught, through avoiding insistence on detailed recall when an "idea" is sufficient, through teaching nothing which does not serve a purpose which nothing else will serve—by these three means

alone most teachers can secure for themselves far greater opportunity than their scheme of teaching now provides, for getting their students to stay permanently taught with respect to things which are essential.

And even with respect to essentials a certain measure of economy is possible. Students learn most economically when they learn "well" from the very beginning. Once an essential knowledge or habit or skill has been presented, therefore, its mastery should be insisted on. It should be interesting and recurrent and effectively usable—all three; but more than that, it should at no single point be permitted to be only half-learned.

These various economies will not permit everything that is worth teaching to be taught so that it will stay taught. They may, however, allow more than mere covering of ground in the case of at least the most important items of learning; and to this extent they may promote, even under present conditions, a kind of teaching through which students retain accurately and permanently the things they learn.

THE DIVISION OF COÖPERATIVE ENGINEERING EDUCATION

Committee: F. E. Ayer, D. C. Jackson, Jr., C. W. Lytle, K. G. Matheson, J. E. McDaniel, H. Schneider, E. Willis Whited, W. H. Timbie, Chairman

Starting with this number of the JOURNAL one page of each issue will be devoted to news and short articles of interest concerning Coöperative Engineering Education.

Under the direction of President Matheson, as Chairman of the Program Committee, the Division is already laying plans for its program at next summer's Convention to be held at Purdue University.

W. H. TIMBIE.

Some Coöperative students take the attitude that their sole job is to make good with their work and that their responsibilities cease when the whistle blows. To combat this tendency, we require that all Coöperative students prepare technical reports on some phases of the work of their employer twice a month. The Department of Coöperative Work arranges with the firm to have these reports read and approved by a responsible member of their organization before they are sent to the University. The fact that these reports are read by his superior, and often, in addition, by an executive, encourages the student to make them as accurate and complete as possible. This is because they affect, not only his University grade for the period of work, but also, and more important, the opinion which his employer forms of him.

We find that the employers are very glad to coöperate with us and to take the time to read these reports. In fact, many students have to rewrite their reports two or three times before they can secure this approval. Obviously, after this has happened to a student once or twice, he takes more pains in preparing his later ones.

After watching the effect, both on the student and on the employer, of requiring these reports and of having them signed by the employer, we feel that we have raised the standards of the coöperative work a considerable extent.

E. WILLIS WHITED.

REPORT OF CONFERENCE ON COÖPERATIVE ENGINEERING EDUCATION AT THE 39TH ANNUAL MEETING OF THE S. P. E. E., MONTREAL, CANADA, JUNE 26–28, 1930

RAILROAD WORK AS VALUABLE PRACTICAL EXPERIENCE FOR COÖPERATIVE STUDENTS

By J. E. McDANIEL

Georgia School of Technology

The Georgia Tech Coöperative Department was founded in 1912 with an enrollment of only a few students who could be counted on the hand. For five or six years it struggled desperately to survive when many of the older professors considered it too costly and wasteful for educational experiment. Today, or this academic year, the Department has a registration of over six hundred. This past summer over four hundred applicants were refused admission to the freshman class principally because of the rigid entrance requirements for this particular department; only students who have attained high scholastic rating in their preparatory or high schools, being at least in the upper third of their class, are admitted for the Coöperative course of study.

The alternation period is four weeks: while one section is at college the other is at work, each section exchanging the place of the other every four weeks over the duration of five years. The students have three weeks' vacation within a year, and are given the identical courses as the four-year men, with the exception of a few shop courses or a slight variation in some course to suit the needs of students who have had considerable practical experience. I wish to add that the Coöperative students do not seem to have their schedules too crowded, or to have unusual difficulty in finding sufficient time to prepare for the next-day classes. Some of the very brightest find time to participate in extra-curricular activities. The honor societies, such as Phi Kappa Phi, Tau Beta Pi, etc., have large numbers of Coöperative students.

About one hundred and fifty of the six hundred Georgia Tech Coöperative students this year voluntarily asked to have their practice work with railroad companies. For some reason or other many young men have an ingrained fascination for railroad employment. Even when they were infants they cherished the idea that when they became of age they would have an opportunity to

operate a huge locomotive. Although many such ideas may have vanished when the same young men entered college, some of them as Coöperative students are still eager to work for a railroad company.

I often feel much gratified when interviewing such students, because now so many students who matriculate for a college course are obsessed with the desire to acquire what we might call the by-products of college life. Their foremost ambition is to join some fraternity, keeping in direct contact with all the social phases of college life, or to get distinction in athletics or some of the well-known extra-curricular activities.

Some of these railroad students may indulge to advantage in these by-products, but they are not likely to over-emphasize the irrational fads and fashions of the moment. They probably will consider the habits, aptitudes, and general characteristics of the regular shop apprentice and of their fellowmen as by-products of their courses of study, thus subconsciously getting a practical insight into economics, sociology, ethics, and psychology. Perhaps the railroad student could have nothing more beneficial than this study of practical humanities which might be termed the human element of engineering. This sober, serious aspect which may characterize a majority of the Coöperative students is well worth while; the contrast of social conditions in railroad employment with those of college life will prompt anyone to consider the serious problems of civilization. With the fairly well balanced students—only the Georgia Tech applicants and students who are above the average in intelligence and bearing are admitted into the Coöperative Department—there is very little danger in over-emphasis on the sordid aspect of business found in big corporations, or more particularly in the duties of a railroad shop.

At Georgia Tech the Coöperative students who wish to follow railroad work are apportioned according to their matriculation blanks into mechanical, civil, and electrical engineering groups. The mechanical engineering students are placed in the shops; the civil in the maintenance of way and bridge construction departments; the electrical in the signal department and in the electric shop.

The railroad companies will not set uniform regulations as to the exact kind of work on which at first to place the Coöp, but generally the mechanical engineering student is started in the foundry or forge shop where he will remain three months or longer; then he is given about nine months divided between the car department and the machine shop; later about six months in the boiler shop; his fourth year in the erecting shop; and his last and fifth

year in the drafting room and in the test department. This schedule of practical work was inaugurated by the Central of Georgia Railway Company about eight years ago and is more or less carried out with several of the other roads using Georgia Tech students. However, as I said before, no hard and fast schedule of work rotation is carried out uniformly by any one road, or by several roads. The students are shifted about on the work as the road finds opportunity for adjustment. As a general rule, every graduate has found some experience in every department aforementioned during his five-year career. The last year—when the student has opportunity to take part in some design work, in testing steel, and in fuel analysis—is the most interesting according to the opinion of most of our graduates.

The electrical engineering students are placed first in the signal department where they live for a year or more in box cars along the tracks doing laborious tasks of every nature, but giving a large portion of their time to the signal installation and repair work of certain sections and divisions of the road. Their duties are to maintain transmission lines, to keep in perfect order the block signals showing the automatic color light. When new rails are laid the students often insulate the joints and help lay the track circuit. The third year the students are given some experience in the electric shop where they have duties of an electrical nature, such as general electrical repair, car lighting, armature winding, etc. Often they are given some electrical engineering experience in and around the power house. The last two years they are "put over" the drafting board of the signal department, where they make blue prints of the field work.

The civil engineering students are placed for one year or more in the roadway department where they learn to do the hardest kind of labor, such as the laying of cross ties and rails in the rebuilding of a track after a wreck, or after a washout from rainfall. The next two or three years they are given experience in the maintenance of way department where they have both field and office work. They may have to adjust any part of track which is out of line so that the curves and spirals are fitted properly. They often have to outline or map a drainage terrain in proximity to the road's right-of-way so that the proper deposition may be had at court. Frequently they will make a survey of a certain railroad crossing which becomes important evidence in a court suit. or they will have to make a survey of some side or spur track which will serve the needs of some individual or private company.

The last year they sketch the A. F. E. blanks (Authority for Expenditures), getting the measurements for anything relative to

maintenance, even such as coal, brick, and lumber bins. They also keep an outlay of all bridges on lines, showing alterations and changes on same in the field book. They record placement of floors on bridges indicating spacing, such as ties, stringers, and floor beams. The aforementioned outlined practical experience which the civil engineering student may obtain in railroad employment, also which other engineering students may acquire under the Coöperative Plan in railroad work, should be invaluable to engineering graduates.

Where do such graduates find permanent employment? Some remain in a supervisory capacity with the old employing railroad companies; others find employment in a supervisory capacity with railroad companies that have never tried the Coöperative Plan; others follow some kind of engineering other than railroad work; others do not follow engineering at all, usually getting some kind of sales work of an engineering firm.

In conclusion, I wish to say that the Georgia Tech Coöperative Department feels that both the students and the railroad company are benefited by this Coöperative Plan of education which I have tried to outline in a very brief way. I believe anyone will say that the student is much benefited by such practical experience; in fact, the old adage that "the most effective teaching is the practical work" is realized under the Coöperative Plan. As an illustration of what the Central of Georgia thinks of these student apprentices, the president of the road at the Georgia Tech commencement exercises every year delivers to the students who have completed their five-year practice program in the Central of Georgia Railroad's shops a formal certificate indicating a completion of work held in conjunction with Georgia Tech.

Discussion

R. S. King: It has been the author's pleasure and my pleasure to work with coöperative students for quite a number of years. I took particular pains to inquire of these boys just what particular good they had derived from the railroad coöperative work. The author and myself are of the opinion that these men have had a most excellent opportunity to study the human ties, if you want to call it that; in other words, human nature. The railroads present in their shops a most excellent opportunity to train the boy, that is, if he has any tendency toward pig-headedness or swelled-headedness they take it out of him pretty quickly. I think that it is certainly an excellent vehicle for that purpose.

I was rather surprised to find that the students were very much alive to the railroad questions that come up. I asked them whether

they ever entered into any discussion with their foreman or men, with whom they worked, and I found that the question of the car loadings and the recapture law, and all those sorts of things, were very familiar to the student, having a tendency to bring out the economic end of railroad operation.

They also are very much alive to the present-day question of railroad shops entering into, you might say, the contract system. The tendency is for a number of our railroads to contract all of their repairs and all of that work rather than do it themselves. Some of the criticisms that have been entered against the railroad shop is the fact that the student is not fitted for modern production, that is, there is not a question of mass production there. Also, the student work in the railroad shop is rather rough, rather unfinished. Therefore, he may have some bad habits to overcome when it comes to close machine construction. However, that is not a serious bad habit.

The shop as a whole is a most excellent method to teach the young engineering student, first, organization; second, the necessity for hard work in times of stress; third, loyalty to the company for which he works; fourth, how to get out of difficulties by employing the tricks of the trade and often to make substitutions: fifth, that practice has solved many things that mathematics does not have the apparent solution for at the present time.

The mechanical coöperative student does not stick with railroad work as much as he should because the roads do not offer sufficient incentive for advancement. The idea of seniority has killed off the ambition of many who enter the railroad service. In spite of some of the above criticism, it is an established fact that the railroads offer good vehicles for coöperative education. Some of our southern roads require attendance at many instruction classes and encourage night school attendance in air-brake and such other classes. Certificates are awarded to those who finish.

THE COÖPERATIVE PLAN APPLIED TO AERONAUTICAL ENGINEERING

By F. K. TEICHMANN AND C. W. LYTLE

New York University

Orientation

The problem of orientation looms large in all coöperative work, regardless of the department. Early practical experience necessitates early consideration of each man's aims for the future. It is the experience of most of us that these aims are extremely broad, sometimes merely negative and rarely based on accurate knowledge of the profession as actually carried out. Despite this situation and although we keep our first two years of engineering identical for all departments, there is a surprisingly small amount of departmental transfer, during the undergraduate course.

The work of orientation is therefore mainly a matter of finding the subdivision of the main field which is most suitable for the individual student's qualification. The breakdown here submitted for Aeronautical Engineering, Table I, is approximately a true picture of conditions in the field and is the first thing an applicant for coöperative work needs to face. Some of the men know at once which subdivision comes closest to their qualifications and tastes, but most of them are unsure of either their qualifications or tastes and some are very inconsistent. On the other hand, those who have potential research ability will usually have a definite enough realization to allow the coördinator to accept it as probably true.

TABLE I

Breakdown of Whole Field

Aeronautical Engineering

- (*a*) Research
  - Mathematical
  - Laboratory
- (*b*) Manufacture of Planes
  - Land planes
  - Amphibions
  - Seaplanes
  - Designing, Producing, Experimenting, Maintaining
    - Fuselages, Wing Structures
      - Metal work
      - Wood work
      - Textile work
  - Designing, Producing, Experimenting, Maintaining
    - Landing Gears or Pontoons
    - Accessories
      - Instruments
      - Rubber goods

TABLE I—*Continued*

(*c*) Manufacture of Engines

Designing Producing Testing Overhauling	V-Type Radial Inverted in-line Broad Arrow Opposed

(*d*) Transport Operation

Design and Construction of Airports	Runways Flood lights Buildings

Layout of Airways
Maintenance
Routing and scheduling of service
Communication
Commercial

Financing
Accounting

Prevention of accidents
Publicity
Meteorological service

Research

We have had some sophomores who insisted on research work whom we would certainly not have sized up as research men on our own powers of observation. We mention research first, because the number of men who are capable of this are relatively few and are likely to be as definitely unsuited to the non-research side of engineering as they are suited to the research side. Men of this type have particularly good opportunities in the aeronautical field today because of its newness. They are the ones who usually take an extra year on the campus, and therefore, under our Coöperative Plan, do not take the year out in industry between senior terms.

Manufacture of Planes

The next subdivision of importance is the manufacture of planes. It is in this field that we have had the greatest opportunity for placement. Men usually start with ordinary manual work, either in the metal, wood, or textile departments, eventually rotating through all three. Those who make good sufficiently to return to the factory for successive periods are pretty sure to win promotion to drafting or experimental work. Again because of the newness of the field, drafting is a relatively larger opportunity for our students. There is no company which is not making changes in design. The ordinary employee cannot be used for this work and we find that we can place quite a number of men, even sophomores, in this work. We prefer to start sophomores on

production work so that they will be more resourceful for design when it comes later. In dull times we do, however, place beginners on drafting to avoid competition with tradesmen.

Manufacture of Engines

Up to the present, this field has not attracted as many of our aeronautical students as might be expected. The typical student yearns to fly or to get close to the plane itself. If he is primarily interested in engines he is more likely to take the mechanical course than the aeronautical. On the other hand, Mr. Charles Lawrence of the Curtiss-Wright Company has said, "We cannot afford *not* to coöperate with your Aeronautical Engineering Department." This indicates that manufacturers of engines feel the need of aeronautically trained engineers and that we may have an increasing number in this field. As in other fields, the two-year cadet course for four-year graduates will probably be shortened for coöps.

Transport Operation

This subdivision promises sometime to be the most important of all, but it is not so at present. We base this forecast on the history of railroading and other transport developments, but just when it will become the most important we cannot say. Unfortunately the high degree of hazard in aeronautics has retarded the use of undergraduate men to a considerable degree in this field. Companies operating flying lines give us two reasons, either one of which would account for their reluctance to hire inexperienced men. In the first place they usually have their own flying schools and find that graduates of these schools always furnish waiting lists for employment which the company feels somewhat obligated to meet. In the second place, these companies are so fearful of accidents that they object to employing any but experts and dare not use the job itself as a means of training. We suspect, however, that there is another reason, namely, that high school boys are taking flying courses and volunteering to fill these jobs without asking any wages! Because of these conditions we have so far succeeded only in placing men through personal contact or by getting them in through some flying course.

Options in Curricula

It is most unfortunate that the proportion of operating jobs to manufacturing jobs is so small, because we are at the same time forcing the majority of our aeronautical students into what we call the Transport Option. The alternative option is called the

Technical Option and is limited by our present capacity both in teachers and equipment. Those taking the Transport Option will be given the general courses in Aeronautics and will receive the same degree, but instead of the more technical design courses there will be given courses which were formerly segregated under the heading of Industrial Engineering. We believe we are justified in keeping the Technical Option small and also in encouraging a majority to take the business end of engineering, but we have not as yet found any way of getting the appropriate jobs for this majority. We are obliged to start most of them in factories just as we do the technical option men.

Placement

The manner of determining the subdivision most suitable to each man is in no sense different from that used for the other departments. The Coördinator indicates the break-down and draws the man out in regard to his qualifications and tastes. It is usually found necessary to do this in a series of about three interviews. The first one is general, the second one is specific, although not narrowed to a choice of any single company, while the third one attempts to narrow the issue down to the one best opportunity. Much of the Coördinator's contribution comes through his field contact which enables him to bring before the student the actual possibilities which fall within the limits of the personal qualifications and tastes. While there is some trial and error in the first placement, there is not as much of it as some might expect. Neither is it difficult to persuade the student to stay with a single company for all or most of his periods if the company is reasonably large, and fair in its treatment. There is ample evidence to the student that he is more likely to gain in promotion and to get a more complete, unified experience, than if he jumped around inconsistenly from one factory to another. While there are exceptions to this rule, we believe it is generally true that it is better to have a student gain a thorough knowledge of one company than to gain a superficial knowledge of several.

Specialization in College Comes Late

Not only are the first two years of engineering curricula identical for all departments, but the undergraduate curriculum in aeronautical engineering is identical for the first three years with that of mechanical engineering, except for one elementary course in aerodynamics and airplane design given the second semester of the Junior year. Specialization in aeronautical engineering, there-

fore, really does not begin until the Senior year.

The first period in industry comes during the summer after the Sophomore year. Although this period may determine the student's future, it is mainly intended to check his own opinions. The particular work he does is not therefore so important provided he has every opportunity for observation and absorption of aeronautical lore. In fact, there is so much for him to learn in a general way that we have sometimes accepted factory work which was not strictly aeronautical. The job should, however, be close enough to the aeronautical engineering field so that he can definitely decide whether he has been justified in electing the Aeronautical Engineering Department. The second term of work, or Junior summer, should show him which of the special courses will best meet his needs.

Example of Work

Suppose, for example, that a student finds employment in a servicing hangar at an airport. The tasks are simple and such that any common laborer might perform them, but the opportunities for an interested student to study air transport operation, aircraft structure, aircraft engines, airport personnel, etc., are unlimited. If the student is interested in aircraft design, he will soon observe whether the airplane structure is wood or metal, steel or aluminum alloy, riveted, welded, or bolted, whether the pilot, baggage, and passenger arrangements are adequate, whether the airplane is single or multi-motored, high or low wing monoplane, and all the other ramifications of the aircraft structure. All of this is drawn out by means of observation guides and bi-weekly reports.

If his interest is aroused in air transport, he will study the airport layout, the hangar facilities, the size and accommodations of planes, seating arrangements of transport planes, as well as costs and operating routine of an airway. Servicing planes will give first hand information of aircraft engines. A study of dimensions and areas of tail surfaces, wings, ailerons, etc., and of their relations to the three axes of the airplane, as well as conversations with pilots will soon indicate which plane is more manoeuverable, more stable, more efficient, and if he has any intelligence at all, he will begin to appreciate the rudiments of aerodynamic theory.

A Coöperative Class Resourceful

By his first term Senior year, the coöperative student will have a fair conception as to what it is all about. Since the more technical courses are limited to the Senior year, it is necessary to cover a great many phases of aeronautics rapidly. Classes made up

largely of coöperative men can cover this ground more comprehensively and concisely because they have a foundation of knowledge and interest. In other words, the teacher does not need to spend much time on elementary explanations.

By way of illustration, suppose a student is interested in aircraft design. He will take the technical option of aeronautical engineering and in his Senior year will make a complete design of an airplane. If he is a coöperative man he will incorporate in his design many features which he has seen at first hand during his periods in industry. He will also have the confidence to add many of his own ideas.

It is well known that any coöperative class is resourceful in the matter of recent practice developments since each man contributes from his own intimate experience. In a field as new and changing as aeronautics this is doubly advantageous. No collection of texts, certainly no one teacher, can keep up immediately with the rapid advance. A whole group of coöperative men returning to college from diversified companies can and do act as a most efficient clearing house. In reading the reports we are amused at the usual enthusiasm shown by each man for his company's designs and methods, but in class these various matters are compared and constructively criticized. Just how rich this resource is may be realized by a survey of the accompanying list of employing companies.

TABLE 2

List of Companies Which Have Recently Employed Aeronautical Engineering Undergraduates on the Coöperative Plan

This list speaks for itself, but we may briefly call attention to a few of the interesting aspects. It will be readily seen that the list covers every subdivision of the work, every size of company, and a considerable geographical area.

Alexander Aircraft Company, Colorado Spa, Col.
American Aeronautical Corporation, Port Washington, New York.
Atlantic Aircraft Company, Hasbrouck Heights, New Jersey.
Aviation Corporation (U. S. Aluminum Co.), Buffalo, New York.
Bellanca Aircraft Company, New Castle, Delaware.
E. W. Bliss Company, Brooklyn, New York (Jupiter engines).
Brewster & Company, Long Island City, New York (Pontoons).
Brooks Field.
Brunner Winkle Company, Ridgewood, New York.
Chance Vought Company, Hartford, Connecticut.
Curtiss Aeroplane & Motor Corp., Buffalo, New York (Engines).
Curtiss Aeroplane & Motor Corp., Garden City, New York.
Fairchild Manufacturing Corp., Farmingdale, New York.
Fokker Aircraft Corp., Passaic, New Jersey.
Gates Aircraft Corp., Corona, New York.
Great Lakes Airways, Erie, Pennsylvania.

TABLE 2—*Continued*

Great Lakes Aircraft Corp., Cleveland, Ohio.
Hall Aircraft Company, Buffalo, New York.
Keystone Aircraft Company, Bristol, Pennsylvania.
Langley Field, Virginia.
Loening Aeronautical Engineering Company, New York City.
Glenn L. Martin Company, Baltimore, Maryland.
Master Aircraft Company, Rochelle Park, New Jersey.
Mitchell Field, Long Island.
Naval Aircraft (U. S. Navy Bureau), Philadelphia, Pa.
New Standard Aircraft Corp., Paterson, New Jersey.
Nicholas-Beasley Airplane Co., Marshall, Missouri.
O'Connor Transatlantic Airways, Inc., New York City.
Pioneer Instrument Co., Brooklyn New York (Flying Instruments).
Sikorsky Aircraft Corp., Bridgeport, Connecticut.
Skyview Lines, Inc., Buffalo, New York.
Wright Aeronautical Corp., Paterson, New Jersey (Whirlwind Engine).

Last Period Important

Upon completion of the first term of the Senior year, the student is ready for the triple period, that is, one year in industry. College has perhaps crystallized his thinking and raised a great many questions which he would like to settle. He is now ready to be placed in some work definitely allied with his interests. This placement is the most important of all because it is pretty sure to determine his future. The contacts he makes during this year in industry, as well as the reputation he establishes, will usually secure him a good position upon graduation. Up to this June, every New York University graduate in aeronautical engineering has promptly secured a position in the aeronautic industry. The present depression has made it impossible to place all of this year's graduates in the field and some doubts have been raised as to the immediate future.

Close Relations Between College and Industry

The relationship between the aernonautic industry and the college is a most happy one. The industry requires a great deal of research in aerodynamics, and structures, as well as other phases of aeronautics. Coöperative students often bring problems for research back to college and these problems form the basis of excellent theses. The Daniel Guggenheim School of Aeronautics is well equipped for this research work. We have two wind tunnels, one nine feet in diameter with an attainable wind speed of 115 miles an hour, and a smaller one four feet in diameter with an attainable wind speed of 45 miles an hour. These wind tunnels are used for determining the aerodynamic characteristics of air-

craft or their component parts. These wind tunnels are at the entire disposal of the students. In fact, two coöperative undergraduates have been employed here on company research.

There is also at the College an engine testing laboratory for research work on aircraft engines, either air-cooled or water-cooled. In addition there are facilities for structural investigations of wings, ribs, tail surfaces, and fuselage structures, characteristics of shock absorber struts, and the like. Flight testing instruments and calibrating apparatus are also available. The calibre of this research work is high and the coöperative student may use it to strengthen his hold upon a position.

The employers in the aircraft industry are giving preference to men with previous experience in the industry. In fact, there is not a large supply of old experienced engineers as in other fields, all of which gives the coöperative plan a real importance.

Conclusion

It is evident therefore, that the aeronautical field has all the need of the coöperative plan which has been demonstrated in the older engineering fields. Some of these needs are greater than in other fields because aeronautical engineering is still new and developing with phenomenal rapidity.

ENGINEERING COURSES IN SCHOOL OF BUSINESS CURRICULA

By GEORGE FILIPETTI

Columbia University

Coöperative education, at least in the sense in which you are using it, has little connection with the title of this paper. An explanation of how the two were brought together would consume the fifteen minutes which Professor Jackson has so definitely set as the limit.

At the time the suggestion was made that this subject be discussed it was my understanding that the meeting was to be one of engineers only. With that in mind, I have raised certain questions which it is hoped the engineers will answer.

The title indicates a reversal of the approach to the matter of curriculum-making which many engineering schools have had under consideration for some time. Some of you have been interested in broadening engineering courses to include business subjects; I am interested in broadening business courses to include engineering subjects. Recognizing the fact that their graduates have frequently been called into positions of general management and into other phases of business operation, these schools have enlarged their curricula to provide business courses to supplement their basic, engineering offerings. What to exclude and what to include has probably proved to be a very nice question. It has been answered, very largely, by offering cost accounting, finance, personnel and marketing courses from the field of business, and superimposing these upon the engineering curriculum.

The Purpose of Business Education

I have always felt that if the question were raised as to the purpose of engineering education, the responses from those connected with engineering schools would be quite uniform. It has seemed, that if they were asked to indicate the desirable curriculum approach to the accomplishment of that purpose, that there would be considerable unanimity in the choice of subject matter. If these assumptions are correct, they are somewhat in contrast with the situation as we find it in business education. In the first place, the purpose is not so definite, and in the second, there is not the same degree of unanimity in the choice of subject matter to accomplish an accepted purpose.

The explanation of this condition is not a particularly difficult one. With two or three exceptions, collegiate business education, in the form of distinct schools of business, is quite new. The school of business is the infant member of the university family of colleges. In some places it is considered *l'enfant terrible,* and other members of the family throw up their hands in holy horror at the coddling and the attention which is given to what is considered an already spoiled child.

As a new field of education, objectives may be expected to be somewhat hazy. The materials upon which to build the curricula are still in the process of being organized; indeed, some of the materials are just being discovered. It is not unlike the early history of education in science, in medicine, in engineering, and the other branches of learning. As materials were collected subjects became more and more finely subdivided, then new combinations of these finer subdivisions were effected. Chemistry becomes bio-chemistry, physical chemistry, mathematical chemistry, thermo-chemistry, electro-chemistry; general medicine grows into many specialties, and we have one man to remove tonsils, another to take out an appendix, another to remove a kidney. Today the question is raised as to whether more should not be required in the form of general medical education lest the specialist needlessly remove tonsils or other parts of our being. And in engineering, is there not considerable advocacy of less subdivision and more emphasis upon common principles? In other words, these older schools are changing their objectives.

The desirability and the form of business education is dependent upon what is established as its purpose. The means of realizing the desired end is determined largely by the availability of materials and equipment, and the ability to make use of them. The stated objectives or purposes vary widely. On the one hand there is some confusion between the purpose of general and business education. This is indicated when the end includes, as it sometimes does, the making of "good citizens". There is also variation in the conception of the breadth and depth to which the curriculum should go. This is evidenced in the following list of stated purposes:

1. To develop high class clerks.
2. To develop a social attitude toward business.
3. To train for professional careers.
4. To educate in the principles of business.
5. To train for general management.

Although these are fairly wide differences, the most generally accepted purposes are to provide technical experts and business executives.

Accomplishment of Purpose

If these are accepted as the basic purposes, the next question to be answered is what the technical expert and the business executive should know. In addition to certain technique, it would seem that they should have a comprehensive grasp of the setting and the operation of business. But what is the setting and what are the operations? If summarized, we should probably agree that business is the development and operation of an organization to produce and distribute, or to aid in the production and distribution of goods and services which people want and for which they will pay. The motive force is profits.

Three factors, then, are basic—production, distribution, and profits—and the techniques developed are such as will aid in these directions. Some of the techniques have been more or less fully developed, as in accounting and statistics. In the field of distribution, various courses in marketing have been offered and the list is being enlarged. Many of the agencies which have developed in economic society to aid in production and distribution have provided subject matter for courses in special fields, as in banking and transportation. An outstanding weakness of school of business attempts to teach modern business is the failure to provide for an understanding of the part played by the machines in what is recognized as a machine age. The problems and the effects of mechanization are subjects of the hour. Many business graduates will go into manufacturing plants; they will sell machine-made goods; they will be connected with companies financing manufacturing enterprises, yet they do not think in terms of machinery.

The Effects of the Machine Age

There is a great deal of discussion these days about the effects of machinery upon the worker and upon the consumer, and the subsequent effects upon modern civilization. Machine production appears to be synonymous with "mass production" and the effects upon the operator and the user of the product are supposed to be devastating. "Robots or Men", "Men and Machines", "Love in the Machine Age", are titles of books, which have appeared within a relatively short time and have discussed this subject. Labor at times resists the installation of machinery and governments attempt to regulate the conditions of machine operation. This year at least one set of college graduates listened to an address upon the destruction of individualism in the machine age. We may ask to what extent individuals were distinct personalities before the advent of the machine? Under the manorial system, in the period

of household industry, in the craft period, how distinct was one individual from another; one household from another; one life from another. In China and India today, in those sections untouched by the effects of machine production and the consumption of machine-made goods, how individualistic are the persons in those communities; how great are individual differences in dress, in thought, in thought processes, in mode of living, in food consumed. We repeat the words "mass production", "mass consumption", and "deadening uniformity", as all inclusive expressions of machine production, as absolutely interrelated, but are they not catch-phrases? Look at a colored moving picture of a group of people in a non-industrialized state. Are their head coverings any more individualistic than those of our women in industrial America; do these coverings vary more in shape, size, color, and decorative effects? Look at their footwear, if visible, and compare it with the covering on the quite visible feet of American women. Is there greater variety in design, or in color? Look again at an assembled multitude of women in England, France, or America, and note the gowns which they wear. Is the "deadening uniformity" greater than that of our hoopskirted forebears of colonial times?

The machine age has given us newspapers, magazines, books, radio, moving pictures, quick and low cost transportation. We see distant places and strange people and learn what they are doing. In the colonial towns people thought and talked in terms of what little took place locally; today they talk and think in terms of what is going on nationally and internationally. The difference between talking, acting and living in the broad and individualistic terms of the death of farmer Brown's horse, or the influence of the devil in the life of the community, or the effort of striving to wring enough from the soil in a twelve- or fourteen-hour day to keep body and soul together—the difference between that, and a life lived in terms of a forty-hour working week, or of what is going on in Fascist Italy, or Soviet Russia, the difference between that and thinking in terms of man-made prosperity and depression rather than in terms of a capricious god of feast and famine, is a difference traceable, largely, to the machine. Steinmetz, Edison, Lindbergh, Byrd, the records of the United States Patent Office, are all striking evidences of the deadening effects and the destruction of individualism which is characteristic of the machine age.

Interrelation of Engineering and Business Courses

Schools of business and engineering schools meet on overlapping fields when they get into production. Courses designated as

industrial management, industrial engineering, industrial administration, factory management, production management, are offered sometimes in schools of business, sometimes in engineering schools, and sometimes in both. If offered in the engineering college in a university the business student may take these particular courses in the engineering school (Michigan). If offered in the school of business, the engineering student may take them there (Harvard). What the school of business is not equipped to do, however, is to give that direct knowledge of industrial equipment and its uses, that knowledge of the operation of the machine shop, the forge and the foundry, which the engineering school is able to give. The uses of lathes, drills and machine tools generally; of jigs and fixtures; a knowledge of the types of machines used in plants to heat, mix, compress, bend, twist, and cut the materials processed; an understanding of the conversion of energy and the transfer of power from the point of development to the point of application—these are phases of engineering education which it seems would be desirable for business students to obtain. It seems desirable first, because such courses give a background for an appreciation of what is involved in business management in a machine age; second, because these courses provide practical information upon certain aspects of business management. What it is possible for the engineering school to offer without an extended list of prerequisites in mathematics and science is for you to answer.

Business Functions and their Interrelationship

Knowledge has been broken down into individual subjects and these have been combined into groups of subjects constituting schools or colleges within the university. But these air tight compartments are recognized as defective. It is not sufficient to teach law on the basis of preceding cases; law is being taught in its relation to psychology, business, economics, and changing social concepts. Business is equally complicated. That fact stands out in the study of any business function. The purchasing function may be considered as properly belonging to the engineering school since it involves materials used upon the machines, the testing of purchases, the establishment of standards, and the determination of the uses of substitute goods. But there is a legal aspect to purchasing in the matter of purchasing contracts; there is an economic aspect, since it deals with questions of prices and price trends, demand and supply, the nature of competition; there is a psychological aspect, since it deals with the reactions of the buyer and seller and the consequent technique of bargaining.

An analysis of other functions of business discloses the same interrelationships and the same ramifications. Both law schools and engineering schools could contribute much to the cause of business education. Some of them feel that the business schools have something of value to contribute to them. When there is such a mutual recognition of service, administrative difficulties growing out of costs, stuffs, and similar problems, are simplified. While the contribution of the school or department to another may not be in perfect balance, the result is a better preparation of the student for the field which he is preparing to enter, and that is the end of the education which he is offered.

Discussion

B. M. Brigman: I have not had the pleasure of going over this paper of Professor Filipetti's, but I am interested in some of the comments that he has made. For the past nine or ten months I have been making a study of the schools of business and commerce with the thought in mind that perhaps in the very near future the University of Louisville might enter into that field. I have found, just as the paper presents, that there is a question as to the ends and the purposes to be attained. A mass of data that have been collected from manufacturers, from commercial houses, show that at the present time, in my mind, there is not a very definite purpose established.

Manufacturers tell me that they would desire to have students who are trained in manufacturing and cost work, who would be familiar with shop work, and who can develop into superintendents. On the other hand, you come to the commerce side of the question and they tell me that they are not seeking superintendents, that they want high-type office managers, men whom they can send out into the highways and the byways of commerce. The same thing practically, almost in the same words, comes from the strictly business side of the wholesale or the large retail departments.

The question, as I find it, is one of curricula, one of proper coördination between the engineering phase and the strictly commercial side. That, in brief, is the experience that I have gained at this time. I wish that I would have had the opportunity to go over this remarkable paper. I hope that perhaps later on when these papers are open for discussion that other problems may be presented.

AN EXPERIMENT IN INDUSTRIAL EDUCATION

By GEORGE B. THOMAS

Personnel Director, Bell Telephone Laboratories

For the purpose of this meeting I thought it would be well worth while in dealing with coöperative education to deal with it from the standpoint that anything is coöperative education in which part of the time is spent in industrial work and the other part is spent in educational work, in connection with some definite educational institutional program.

In the Bell Telephone Laboratories we have a definite principle developed through the years, that we will not employ anyone for a job which is a promotion if there is someone in the organization to fill that job, provided the chap in the organization is qualified to undertake the work. The result of this is that the new members of the organization come largely direct from educational institutions. The youngsters for messengers come from the public schools, who because of economic conditions at home have got to go to work at that time. Many have to go to work at the end of high school. Others go through college, and others go through post-graduate work.

We bring in each year in connection with a definite program, numbers of men, and also women, but, relating to this subject, we bring in numbers of young men from all these sources. Every one of these young men has aspirations the same as you and I. Every one of them has parents who hope for them to achieve something more than they were able to with their economic background and educational opportunity. Every one of them wants his place in the sun. We believe that every one of them ought to be given, through some place or other, an opportunity whereby he can qualify to the biggest that is within him for the God-given endowments which he has.

Consequently, having a corollary to this proposition, that if a person is qualified to do the job, if educational opportunity does not exist where they can become qualified, we attempt to coöperate with each and everyone of those groups where it is sufficiently large to justify it, so they can first become better qualified to do the job at hand, and then remove their handicaps in relation to promoting them.

In this program we have developed for the man-power needed for our business an instrument-maker apprentice course, where the young men who are interested in becoming all-around skilled me-

chanics go into the model shop under a definitely prepared program, and have six hours a week work in mathematics, drawing, and the things which they need, to understand better how to read blueprints and how to set the machines, and so forth.

That is not exactly engineering education, but the other functions we have are more along the lines of engineering education. We developed back in the War a training program for high school graduates. Why? Because the supply of people was not available to do the technical things needed, and the men wanted a reasonable opportunity to progress. Engineering graduates were all going into government service. We had to get the jobs turned out with the best equipped personnel we could possibly handle. We tried to experiment by educating young women, college graduates, to do engineering work.

When the War was over and the young men became available, we could not satisfy the young women upon the definite basic aspirations which they hoped to achieve in engineering, with the social background and concepts which we crude human beings have, especially the male factor. The young women felt that since they were doing a technical job they should be able to go forth, climb a ladder, go out and do an installation job, and go here and there. They said they were willing to be sent to San Francisco on a half hour's notice, but social concepts and the rest would not allow it somehow.

Then the next proposition. The young men were selected groups because we had from six to eight applications for every job we got. They were given competitive examinations. We are using the engineering applicant tests, which are the same as those developed by the Iowa placement tests and other tests. We find those young men in an intelligence ratio on the whole are the upper half of those entering engineering classes in colleges.

We also have another principle, that if the young man can definitely go to college in any way whatsoever we advise him to do it. We have talked with many an applicant who came in for a job saying he wanted to get to work because he had economic pressure at home, or because he felt he would learn more rapidly by working and studying at night. We have shown him how it was possible, through scholarships, or working at this, to really put the program forth of going to school.

The reason we do that is because we have found, by the experience of a training program for high school graduates which has been in operation for twelve years, this very simple thing: The salary progress of those high school graduates who were successful in the training program is not as rapid in the grading as the salary program of well-trained, selected groups of college men whom we

employ after graduation. If that is so, and a man can get a program of training which will be most effective for him, we believe we should advise him to take the type of training which in so far as we can tell will give him the broader prospect and the greater opportunity.

We have developed also a training course for drafting assistants, which differs from that of the boys going into the laboratory, because the drafting man goes in more to do designing, and the laboratory assistant goes more into the development aspects through experimentation. That drafting course differs only in this respect: that the content of the class work of six hours a week is different from the content for the fellows who go into the laboratory. In the laboratory they get a little more calculus, a little more analytical theory of electric circuits. In the drafting room they get a little more of the emphasis upon mechanics, upon designs, and upon the strength of materials.

We have arranged also a course where the experts in the business give the benefit of their experience to the neophytes. This we call our After-Hours Training Course. We started that twelve years ago. A few people who are recognized as experts gave classes before and after hours to see whether there was real demand and place for it in our business. We got requests way over and above anything we imagined would happen. There were some 700 requests for these courses. We thought this was a flash in the pan; that after a year or so it would drop by the wayside as other things. It has been continuing for twelve years and it has been increasing year by year. Most of that is due probably to the fact that the organization is growing, and about 60 per cent. of the registration in these classes come from the men who have come into the organization within the past year. Last year we had a thousand people come before business or stay after business to take these courses.

As an outgrowth of these courses we have published tests of the newer departments in the laboratories, books on differential equations, Fletcher's books on the fundamental principles of speech and theory, bringing out through the available educational institutions the actual coördinated information which is brought together through these courses.

We have found they have been highly beneficial within the organization for the purpose of collating, collecting, and coördinating the material which is in the minds of several people. Through these courses they have been put into one source. Some of them may be of service to you people.

We have also a plan for part-time post graduate work at Columbia University. It is at Columbia because we are located in

New York City. The young men who have been on the job for a year or more may apply for this course. If they have done good, consistent work on the job, shown evidence of growth and intellectual curiosity and capacity, they are permitted to go to Columbia for courses which are approved by Columbia and their supervisors. We have had young men who were sort of below average, but they passed. We felt a person doing that kind of work at home was not doing a good job for himself or education; if he was having unsatisfactory family conditions that it might be impossible for him to study, and so on. As a result of this, we have about thirty-five young men who will get their Master's Degree and five of them will get their Doctor's Degree.

We have also an arrangement with the Massachusetts Institute of Technology for coöperative education. This has developed numerous things in our experimental adventures. Five years ago the first group was selected. The young men who wanted the coöperative course were interviewed by the Bell System representatives. They selected a group and this group has gone into the course with five experience programs, alternating fifteen to nineteen months between the time spent at the Laboratory and the Institute. We do not know whether that is really successful or not. We hope it will be. Considering only those who accepted jobs in the Bell System, nobody can tell as yet how highly successful will be the output of the class last year and the class graduated this year. A great majority of the young men have come into employment in one part or another in the Bell System. Some have gone into the New York Telephone Company, some into the Long Lines of the American Telephone & Telegraph Company, some in the Western Electric Company, and some in the Bell Telephone Laboratories.

However, there is this kind of problem. The department which takes a man on part time knows if it gets him after graduation it will have to take time breaking him in anyway. If it gets him as an undergraduate it is perfectly agreeable to take him for fifteen months or nineteen months. Then after graduation if that young man goes to some other department the department which had him all the time feels it was left out without getting and results from the investment of time and influence with the man in his training. You can say since he comes in the Bell System anyhow it is probably an effective things that he got training in one part to be used in another part. It is very hard for a man responsible for output work on the telephone system in the Bell Telephone Laboratories to see it that way.

The students who are put in on full time on the job and are going to any school at night, are also an experiment in coöperative

education. Those young men do not have the freedom of assignment and choice of placement that comes to the young men who are in the coöperative course at the Institute. They are apt to feel, as some of them have expressed, "that the only kind of a bird who gets any opportunity around our business is the fellow who has got money enough to go to college."

We believe our experience and program is such that we can convince those young men that it is not so. Nevertheless, it comes up time after time that you are giving preference to a selected type of group who already has had a better opportunity in life than the other, taking the old Scriptural reference, "To him who has shall be given; to him who has not shall be taken away." The young men feel it deeply. We have got a problem of keeping the men who are on the jobs continuously happy and contented and forward-looking with optimism, the same as we have with the others. It costs a little money but I think the money and consideration is a very minor one.

In the coöperative course in the Bell Telephone Laboratories we have this problem. We have people continuously coming in and saying, "We would like six or fifteen months with the laboratory and we will come without cost whatsoever." The cost is no factor whatsoever from our standpoint. It may be from some other industrial standpoint, but with us it is just a question of whether you can reasonably fit a man into something which needs to be done in such a way that it will not upset the rest of the organization and will actually contribute to the development of a broader plan.

One of our difficulties, at the present time is the young men in the coöperative course having too great a field and they do not want to do the actual kind of job they would be doing if they were graduated, or if they were dropping out of school permanently. They feel because they are attending an educational institution that they have got certain rights and freedoms. They are not living directly in accordance with the industrial concepts and requirements. I would say for the young men who have been in this course, however, that every one of them has been of a high-class type and high-intentioned young men. None of them has taken a single advantage of the fact that they are on this type of course. The coördinators, of course, have emphasized the necessity for playing the industrial game even more earnestly and they are more drastic in their criticism of the young men on the course than we are.

The boys tell us they are more drastic in their criticism of their actions than we are. We are in an embarrassing position.

If we criticize the boys very definitely, at the end of the course they may say, "I will go some other place. I don't like that." You see, we have nothing as a result of our investments. We have got that kind of a problem. I found this out through interviewing students who have gone through the coöperative course with other industrial organizations. About 50 per cent of them would come in to see us and say they were angry with the other organization. The majority of those fellows who came to see us would have accepted our position rather than go to the company with which they had their industrial experience. It is an undergraduate point of view that "having had experience with XYZ Industrial Concern, now that I am graduated I will take the job with P Industrial Organization, because that background will be useful in service."

Those are factors that I do not know how to handle effectively, but with the things that have gone so far in my mind we have come to this conclusion. It is an experiment that so far we do not know whether it is going to give a better all-around trained man on the basis of twenty years from now than we will get from the other types of educational programs. There is no doubt whatsoever that the young man who is taking a coöperative course of a year in our industry, and with a coöperative proposition of five years for a Master's Degree at the Massachusetts Institute of Technology, is a better man for the job at the time of graduation than the man who has not had that fifteen months' Bell System industrial experience, because he has had the background with us. On the other hand, I am not sure yet that the man who has had that five years' educational work and fifteen months' industrial experience with the Bell System is twenty years from now going to have a bigger, broader prospective. If we had to decide tomorrow between the proposition of every educational institution sending in the men on the same type of program that they are using at the Massachusetts Institute of Technology, it would be impossible for us to do it, as I see it, and conduct our business.

On the other hand, it may be better through the experience we will get in the next five or ten years. We have faith in it and we are going to continue. We may develop methods which may make it feasible to extend this same principle quite a bit further than it is at the present time extended, but the great value of a coöperative course at M. I. T. as compared with most of the others which I have had contact with, is that they have put into it a definite study program, where a fellow who is on the job also has class work which he has to carry on and which he has to do preparatory to passing.

I believe this will be productive of establishing habits of study and continued studies as a man gets on a permanent job, for as

pointed out in all these educational experiments, in the training course for high school graduates we have developed a group there who are growing up with the habit of study while they work. Many have gone to college. More of them have gone to night school at the Brooklyn Polytechnic Institute, and Cooper Union in New York City. We have twelve who got their degrees this year at the night school. The progress of these fellows is good. I was just studying the people who cross the $4,000 per year salary most quickly. There are a group of ten who passed the $4,000 a year salary together out of a group of close to one hundred who graduated in the same year. These were the first men.

What was the educational experience of those men? One of them from high school went to work in the government departments in Washington. After a number of years working in the government departments he went as an assistant instructor in one of our educational institutes. He then went to another. He got his bachelor's degree at the age of thirty-five. That, however, is a definite progressive channel on the basis of salary.

Three others with similar programs, who had to go out to work anywhere from one to five years between high school or during their college course, two of those fellows were high school boys who went to work with the Bell System immediately on graduation from high school. One was a draftsman, having gone to school at night. He went to Cooper Union and got his electrical engineering degree. At the time he got his electrical engineering degree he was a draftsman in the patent department. He took the Patent Office examination at Washington. He went to Washington and took the law course at the George Washington University at night. He took the bar examination and came back with us last January.

Another one, a young chap, who came directly to us from high school, took our training course for high school graduates. At the same time he went to Cooper Union at night. He got his degree at Cooper Union. Going at night removed his requirements for entering the post-graduate work at Columbia University. He has had several patents issued to him and is one of the young promising supervisors in the organization.

As to the others, two did their college work at night while they were on the job, and four of them came from educational institutions scattered over the United States. One of them was from a coöperative system, not from the Massachusetts Institute of Technology but from the Worcester Polytechnic Institute.

That is specific evidence. In ten years from now we will have a successful, progressive, helpful program or not. I do believe we can tell from the salary progress alone whether they have had

a successful, progressive, helpful program or not. I do believe we can tell if the integrating proposition shows they get in that class more rapidly that it is probably more effective.

We, in the Laboratories, are keenly interested in anything which will attract, develop, and hold the right kind of personnel for us to do a better and a more thorough job. We are interested in co-operative education, and anything we can do to help work it out we shall continue to do. We hope and trust that you people with whom we have had contact so far will give us every assistance you can so that the mistakes we are making and have made shall not be repeated, so that we can build a better course and make something from which we can be sure as time passes that we will get more effective results.

COÖPERATIVE EDUCATION FROM THE INDUSTRIAL VIEWPOINT

By E. B. ROBERTS

Educational Dept., Westinghouse Electric & Manufacturing Company

In his inaugural address as President of the Massachusetts Institute of Technology, Dr. Compton laid down several guiding principles which he felt should become beacon lights in the development of engineering education in America. With two other major points, he emphasized vigorously the necessity for an enlarged mutual understanding between engineering schools and the industries and the development of a spirit of genuine understanding on the part of each of the problems of the other. Every worker in industrial education, and I may say almost all from the industry who are even remotely concerned with the problem recognize the great strides that have been made since 1918 in bringing into harmony the requirements of industry with the objective of the schools. No one, I am sure, would even suggest that the problem is solved or that there is no more to be done. As is usually the case in the solution of all major problems involving the harmonizing of many viewpoints, the first step consists of fact finding and of statements of positions, objectives, and ideals. I suspect that coöperative education has reached that stage in its development.

I understand that the term coöperative education as we use it here is in the narrower sense of defining that particular method of engineering training in which alternate periods are spent on the campus under the guidance of the faculty and in the shop, laboratory, drawing rooms or offices of the industry under the guidance of executives whose primary function is not education but production.

In the industry with which I am associated it has been the policy for very many years, in fact since the earliest days of engineering coöperative education as it was applied by the faculty at the University of Pittsburgh, to coöperate with schools interested in this particular educational method. At the present moment we have in our plants young men from Antioch, Worcester Polytechnic Institute, University of Pittsburgh, University of Cincinnati, Akron University, and the University of Detroit. There are, I believe, some other schools interested in this particular method which have approached us with a view to extending coöperative relationships, but in those cases in which we have failed

to respond it has been because it appeared to us, after a careful study of the individual case, that the expense involved was entirely out of proportion to the result to be obtained.

I have no interest whatever in discussing the wide variety of operating principles as practiced by the coördinators at the several institutions. I assume that all those present who are interested in this problem and are charged with the operating of such programs are familiar with the very complete and interesting reviews and comparisons as they were analyzed by Professor Karl R. Wildes of the Massachusetts Institute of Technology in his paper, "Coöperative Courses and Development and Operating Principles", presented before the Northeastern District Meeting of the A. I. E. E. at Springfield, Massachusetts, last May. The chief differences among the several plans it appears are with respect to the length of the time periods in industry and in school, the frequency of alternation as it were, if we may be permitted to borrow a term from electrical science. These vary from four weeks or less duration to periods extending in one case longer than a year, as practiced by Professor Harold B. Smith at Worcester, with the very selected group of men whom he allows at the end of the junior year to go out into industry and remain there fifteen or sixteen months or until the beginning of college in September of the following year.

From the industrial viewpoint and having had the experience of meeting, assigning to work, and following through their courses quite a number of men from all of these schools, I submit as my opinion that the advantage lies with the long period in industry and infrequent change. Such a plan enables the industry to assign the young man to work on such a basis that some real responsibility can be cast on his shoulders and reasonable standards of performance required of him. In our shops new workers, before they are acceptable as members of the work groups in which they are placed, must be put through a learning or instruction period. In some of the simpler operations, two weeks is sufficient to become familiar enough with the work that what we call 100 per cent participation in the earnings of the group may be enjoyed. In more complicated or difficult work, four weeks or two pay periods are necessary and in yet others six weeks or eight weeks before the worker even though he be a college student is sufficiently accurate or skilled to be regarded as satisfactory. So it becomes apparent that, with the less frequent alternation, there is sufficient time on the specific job to permit the boy to enter into the work that is going on around him in such a way that he can have the feeling when he leaves that particular section that he is leaving something there and that he has contributed to the work of that factory; that he has

earned his way. With all the mechanism that may be set up in industry or school for dealing with coöperative students I am fully convinced that the mental attitude above noted is the real objective toward which this phase of the work must be directed.

Another point I would like to make, and I hope there will be some discussion of this phase of coöperative education, is that its cost seems to the industry to be high in proportion to other methods of gaining the same result. I am aware that there is much to be said on this phase of the problem and there are possibly other views. I am not inclined to believe that any of our schools which have gone in the direction of the coöperative principle have done so as a means of making it possible for young men to earn their way through school. I am inclined to believe that, as a means for so doing, it is distinctly less effective as a program than other methods would be. My point is that any specific industry can, in fairness to its other workers and to the capital that is invested in it, judge one means of accomplishing a result as compared with another means of accomplishing the same result only on a basis of economy and efficiency. Coöperative students in a plant without respect to the service which they may require represent a certain amount of training facility. In our plants we are accustomed to measure this in terms of man-months and it behooves those who are responsible for training to apply these man-months in that direction which represents the most advantageous net return for the industry. In comparing our net results over a period of years from our usual Graduate Student Course with the results from our coöperative programs, as I am sure you suspect, an equal input of man-months does not yield trained men ready for responsible work in anything like the same proportion if applied through the two methods. With our Graduate Course, for instance, slightly less than fifteen man-months on the basis of a year's training program will deliver a young engineer to the regular position in commercial, research, or manufacturing divisions. The coöperative programs require forty-two to fifty man-months to produce an equally well prepared worker.

There is, of course, no thought in my mind that we will ever be able to put one of these plans along side of the other on the basis of an exact numerical comparison in the above terms for the reason that those men who have completed college and entered our industry as Graduate Students represent a group from which the major losses have already been deducted. I submit, however, that one of the major problems which those interested primarily in coöperative engineering training must meet is to devise ways and means whereby a markedly increased number of those young men

on whom industry expends its training facilities later be transferred to that industry well prepared for responsible work.

What I have said about coöperation between educational institutions and industry has had specific reference to the practice and procedure as the plan is used in undergraduate curricula. Before closing my remarks I want to touch upon the plan as it relates to the graduate field. Four years ago, as a result of conferences between administrative officers of the University of Pittsburgh and executives of our Company, ideas on graduate coöperative work advanced by Dean Bishop of the University of Pittsburgh were put on trial. Briefly, the plan was that the University of Pittsburgh would build on its experience and develop the same principles in the graduate field with respect to a very select group of young men from our industry. A plan in complete harmony with the existing coöperative program was worked out, to the end that a carefully selected group of young men engaged in technical work within the industry in the design, development, and research divisions, would be allowed to register as graduate students in the University. The officers of the University visited the plant, went thoroughly into detail in a careful study of the existing training program for the more advanced men, and concluded that it was altogether proper for the University to allow graduate credit for some of the more advanced technical courses found there. Specifically, the courses so approved were those which have grown out of the advanced training developed in earlier days by Mr. Benjamin Garver Lamme, so much of whose effort was put into training young men for the engineering side of industrial work.

As the plan is now in operation, of the twenty-four credits required for a Master's Degree, fourteen may be earned in the industry and these represent nine months of assignment at full time instruction. Ten credits are required under the resident staff of the University, and to this end courses are offered by the Graduate School in mathematics, physics, and economics, and the hours are so arranged that these classes are conducted in the early evening. The thesis required, in addition to the twenty-four credits for the degree, is worked out in the industry under the guidance of the same engineers who are engaged most heavily in the advanced instruction. The final and comprehensive examination is conducted jointly by the University staff and engineers in practice. There are enrolled at this time for the Degree of Master of Science more than two hundred and fifty young men. The number of degrees so far granted has been about a dozen, but with the plan now fully in operation, it is anticipated that, with next year, there will be annually a class of fifteen or twenty men completing the program

Courses under the resident staff of the University last term embraced differential equations, vector analysis, advanced calculus, partial differential equations, functions of a complex variable, mathematical physics, electricity and magnetism, and economics.

This program has been in operation long enough for us to feel that it has advanced further than the trial period, and that increasingly as we secure better men from the colleges this phase of coöperative training will occupy a position of increased importance. In the industry, we are very optimistic, particularly on this phase of coöperative education, and I submit the suggestion that those schools which are especially interested in this method should increasingly turn their attention toward the extension of the cooperative principle to the graduate field. There, it seems, lies an opportunity to bring the plan to its highest degree of usefulness.

Discussion

H. M. Morris: What we have been seeing is an extension into industry of university work and methods, and an extension into the universities of industrial interests and their methods. The two are merging and the university lies no longer within its walls but partly outside of its walls. Nor does the industry lie wholly within its property. As a result, both have problems and both have information to give to the other.

One of the chief difficulties has been to teach loyalty to the men in whom the industry invests its money. The university doesn't have to do that. The man graduates from the university and is free to go wherever he pleases. It has become an idea that educated men have held ever since they have completed their education, that their education once gained was theirs to use for service wheresoever they might be called. That idea has to suffer a partial breakdown in view of the fact that industry invests money in men, sustaining part of the cost of their education. Therein lies one of the things that the university can teach through the industry. These men are getting something valuable and it is not unfair that it should be paid for. I do not see anything wrong in the principle that the young man getting part or much of his training from the industry should pay a tuition for it. That will tend to make him more loyal than he might otherwise be.

President Rees: I had the pleasure last week of visiting Drexel. I gave as high an endorsement to coöperative education as I possibly could, feeling in my heart there is a great deal in it for every institution, and that it is a method of procedure which you are all agreeing is growing with more convincing evidence.

Of course there is the restriction that anyone who is contemplating a coöperative education should study the environment very closely and see that the educational methods fit in with that environment. I know, speaking from the employment point of view, that we are having most excellent results in using the product that you turn over to us. I remember speaking down in Drexel of the experience of one of our smaller companies in the Bell System, the Cincinnati Suburban Company. The general manager tells us that he has no college employment problem at all; that all they do is to take the coöperative boys from the University of Cincinnati and they grow up in the business. So there is one of our companies whose entire demand for college men is met from the coöperative students graduating from the University of Cincinnati.

I know in all the institutions with which we have contact that the relations are very pleasant, very profitable to us and to the students, and I take it that it is a fine-growing method of integrating the student during his time of undergraduate work with the problems of business; that it eases the transition between college and industry.

All I can say to you is keep up the good work and develop this type of education to the highest extent you can within the proper environment with which you find yourselves in the institutions with which you are working. I am very glad to see such a large and enthusiastic meeting of the Division of Coöperative Education. It seems to me working more closely within the Society gives strength to the Society for the Promotion of Engineering Education, and I think that it also gives an integrity to the whole field of engineering education that could not be secured otherwise.

I certainly congratulate you all on the very splendid work you are doing and the growing of the movement, the heightening of the standard, and the very evident improvement in the quality of teaching that you are giving to your students under this particular feature.

A. A. Nims: There were one or two points raised by different speakers upon which I would like to offer very brief comments. Mr. Thomas in his discussion made the statement I believe that it was his opinion that coöperative graduates at the time that they graduated and entered business, were probably more valuable than non-coöperative graduates at the same period, but twenty years later the difference probably had disappeared or might even be in the other direction. I am wondering if that really has a bearing on the subject of coöperative education, that is, an unfavorable bearing. At the end of that time would any difference

be due to the type of education received, or due to the individual differences and advantages and efforts which they have made to progress along their own line?

If that is the case, would not the advantage of coöperative education be manifest in the position gained at the time of graduation? Is that not the time where coöperative education proves its own value? The subsequent progress depends more upon the man's initiative and his temperament than primarily on his education.

Then in connection with Mr. Roberts' paper, he made the point that the longer the period the better. Perhaps a little experience along that line will be interesting. When the coöperative course at the institution with which I am connected was laid out some ten years ago, it seemed at that time that two weeks I believe was a very common period of alternation. A somewhat complicated scheme of alternation, involving both two-week periods and four-week periods was inaugurated at our institution. Most of the students at the beginning were on the two-week period. A few of them were on the four-week period, but the balance gradually changed and last year for the first time the four-week period was adopted to the exclusion of the others.

In connection with Mr. Roberts' statement that the cost of development of the young men to a certain stage by the coöperative method was rather high, am I to understand that that is due to the casualties in connection with the course; that is, originally a large number of men are taken in and those who ultimately come through the course have to bear the whole cost of the expense by the industrial concern upon all from that institution?

A little experience there might be of interest in connection with this institution. We started as a night school primarily, and some ten years ago adopted the college course of four years of coöperative work in the day time. Not so very many years ago, in fact four years ago, we inaugurated a twilight course, which permitted graduates of the night school to complete the requirements for the bachelor of science degree in four years, coming to class between the hours of five-fifteen and seven-fifteen at the same time and for the same calendar year as the college courses.

Recently, we have inaugurated the policy that any man who enters coöperative education (and, by the way, our men do not enter coöperative education until they have completed two years of full time college work. That means only the last two years of the four-year course are on the coöperative basis) by means of this twilight course he can practically duplicate the daytime coöperative work and still hold down a job in industry. Anyone who

qualifies at the end of the sophomore year for coöperative work and enters upon it, is considered as practically under contract to continue his coöperative course for two years. If, because of academic work he is in difficulty, that is not to interfere with his coöperative work; that is entirely a college proposition, and arrangements for removing that condition are to be made up outside of his coöperative time, usually during the so-called twilight course. In that respect the twilight course has proved to be of great advantage.

Fred E. Ayer: I would like to bring out one point which has not been stressed in connection with this coöperative work. We have referred to the length of the alternating period, and also the recommendation that this be used in connection with the graduate school work. We have a growing unrest in labor circles in this country which is marked by all industrial leaders, and if we do not give our engineering students contact with labor problems, and not as engineering problems, at an early time in the age of our prospective leader in industry, we will not have at hand the solution of these personnel problems which confront all industry today. If we are going to bend all our efforts toward the production of technical engineers, no matter how proficient they are in the profession, but leave out of the picture human problems, we are liable to run into very serious labor difficulties.

We have to bear in mind that there are 46,000,000 wage earners in the United States, and that if they should wield their influence under proper leadership at the polls they could legislate business and industry out of existence entirely, and if we do not instill into our engineering students a proper realization of these problems, a proper sympathy toward the attitude of the average working man, then in my opinion there are three possible difficulties which the country may encounter. We may go so far as to have a Soviet Government, which is probably unlikely. We may have proper leadership developed in labor circles, and this so-called technical employment at the present time is throwing out quite a large number of college graduates. They are becoming as disgruntled as some of the other unemployed men in the country. Out of those ranks we might develop a leadership, a labor leadership, which would be able to weld together the 46,000,000 wage earners, or a large proportion of them, and get them to exercise their influence at the polls.

Not so very long ago, within the last year, a certain insurance company not only inspected the physical equipment of a plant, the safety devices and so forth, but it made very careful inquiries into the group morale of that particular organization before it

would write the insurance. If that is an indication of what may happen in the future, it is not at all inconceivable that the time will come when the financial circles—and we know that something like twelve or fifteen banks in the United States control 70 or 80 per cent of the financial resources of the country—those financial organizations, will be called upon to take care of the capital requirements of industry in business, and they may not only inspect the physical equipment but the group morale of the organization. If that is the case, then we will be at the point where we will have to consider very seriously the whole matter of employment relations, the whole matter of industrial relations between employer and employee. The point I wish to emphasize particularly in connection with coöperative work is that unless our coöperative students have actual experience in the labor end of the work and can appreciate from personal experience the attitude of mind of the ordinary laboring man, they are not going to develop to the fullest extent the advantages of the coöperative system.

Harold Pender: May I say that I am from Missouri, because I am one of those men that Mr. Roberts referred to as not yet being convinced in regard to the coöperative system. Dr. Matheson looked around the room when Mr. Roberts made that remark. He seemed to think there was not any here who was not thoroughly convinced. Here is one. I am open to conviction, particularly in regard to the graduation work carried on with the employees of the company, the graduate work being given by a university. It seems to me there you would have the right type of coöperation. Let the man be employed and then the university will coöperate with him, but not ask the industry, to take on part of the burden that the university should take on and carry the man through to his graduation.

One reason I am still doubtful on this question is that Mr. Thomas and General Rees did not seem to be quite in agreement. Maybe I should not point that out, but it seems to me to be so. Mr. Thomas was very much in doubt as to how this thing was going to work out. General Rees was quite confident that the thing was fine and was suggesting that you all do all you can to develop it.

Another thing, Mr. Roberts suggested that the longer the period in and out the better. I wonder if you have given careful consideration to the idea of four years in and forty years out.

As an example of that, we have a man in our junior class this year who graduated from a first-class law school. He decided that he was not interested particularly in law; that he wanted to go into engineering. He came back and started in as a sophomore in electrical engineering. He is one of the best men we have. He is

a man of broad experience. It makes very little difference where you get that broadening. I think you might also find that a man who has had four years in college with an A.B. is a better man when he comes to the engineering school than a man direct from high school.

I would like to ask Mr. Thomas if he can give me the answer to this little question. Maybe I am asking things I should not ask. You talked about a study made of the men who had reached the $4,000 salary after graduation. You made a comparison. You did not tell us how long it took those men after graduation to reach that $4,000 salary. I think that would be interesting.

Mr. Thomas: Three of them around eight years after high school; one of them nine; two of them about eleven; and the other four went up quite a way.

W. H. Timbie: I want to assure Professor Pender about this pessimistic George Thomas. If George is pessimistic he has a reason to be. The M. I. T. course graduated this year fifteen or sixteen men, and the Bell System did not get one of them. They got the fourteen or fifteen, but one of them they missed. He wants to be 100 per cent. In being pessimistic, the beauty of it is he sees the problems and does solve them. I do not worry at all about this problem that the coöperative student puts up to industry. Of course it puts up the problem of unrest among the other employees. It stirs up their ambition to get an education and the company simply has to play its part, and it always wants to do anything it can. There is no company that does not wish to develop every man it has to the utmost capacity and ability.

Take the Boston Elevated Railway Company. They did not have a single educational thing going on until we started a coöperative system with them. Now they have a thousand men every year taking some kind of educational work. They employ a full-time educational director. They say it is a fine thing. That company won the prize this last year for one of the most outstanding railway companies in the country, especially in regard to safety, largely on account of education. So this matter of bringing in an industrial problem and an educational problem is the finest thing in the world. It is a good thing for the coöperative course.

As to what is going to happen twenty years from now, I do not know. Our oldest graduates are only seven years out of M. I. T. The last study shows the curve is going up just the way it was three years ago, when there was reported a 55 per cent faster increase every year than the regular graduate as reported by the S. P. E. E. The curve is going up a little bit faster at the end

of seven years than it was at the end of four years, so we are not worried about that yet.

Many of my graduates have written in to me confidentially just what money they are getting and just what the job is. With the man seven years out, the curve is still going this way (illustrating) concave upward. It has not started bending over that way yet, and it is 55 per cent steeper still than the curve for the seven-year men as presented by the report of the S. P. E. E. for the engineering graduates of the country. We give those fellows one year out before we begin to talk. Our men are M.S. men so we can not compare them with the straight B.S. men. We are comparing our men with the eight-year men.

The answer to what the men are going to do is first to get better men. Our method of running the course is simply to pick the best men and put them into the coöperative method. There is nothing against the other methods that will work.

In connection with studying on the outside, there is one little question I want to answer about our teachers. Where the industry is right near the institution that is running the coöperative course, the teacher from the institution goes out to the industry, but we have located a course at Pittsfield, at New York, and at Schenectady. There are quite large groups of men there, so we have one of the engineers of the company doing the teaching. However, he does not do just anything he wants to. He gives them the regular course that the boy would be taking at the Institute. He teaches under the direction of the Institute. His work is all laid out for him just as though he were right in the next room. His work is inspected, and the boys take an examination when they get back to the Institute on that course as though it were given in the Institute.

Just think of the material though that the boy gets on the side! Wouldn't you like it when you were taking different parts of electrical engineering to have had an instructor, a fellow, right on the job teaching you at a regular electrical engineering profession, and giving you all the sidelights, that wealth of material that he has gathered, and his experience? He does that in addition to the regular work. He is held right down to the regular text book instruction. The work we give at the Institute does not compare with the work that these engineers do on the same text and in the same daily assignments.

So the instruction after work is one of the finest things in itself. Then, of course, the habit of study. The only complaint I have about that is that it is rather expensive. One employer complained to me that his company had to buy during the second year for *one*

of these men in his employ after he had graduated, over $20 worth of books for the library because this fellow wanted to look up certain things and it took some rather expensive books to do it. He said, "That boy is very curious. He can not get over that habit of studying. It is very hard to get into, but it is just as hard to get over."

Professor Filipetti: I noticed the emphasis made a few minutes ago by Dean Ayer on the labor side of industry and the need of some training in labor. There are several important sides of industry which should have just as much emphasis as the labor side. There is the question of what makes the consumer buy. The fear of the overthrow of the present government and the fear of the development of the Soviet in the United States may be offset, if you are afraid; but determining what factors will increase the purchasing power of the dollar that the laborer gets, the purchasing power of labor, the factors which make for the purchase of goods, the economy in the distribution of goods made, are all factors equally as important as this emphasis upon the industrial relations themselves. So far as Soviet Russia is concerned I do not think we ought to fear that. As an economy, I hope that the Russian Soviet experiments will continue, and as an economy, I hope that the experiment in Italy will succeed. We will then have an opportunity to compare the Soviet régime with the so-called capitalistic régime.

So you have other phases of this thing as well as the labor phase, which are quite as important. It ought to be an important part of this training of engineers to fit them into the business picture.

T-SQUARE PAGE

FREDERIC G. HIGBEE, *Editor*

APTITUDES FOR ENGINEERING: THE POWER TO VISUALIZE

DR. CLAIR V. MANN

Chairman, Committee on Research, Division of Engineering Drawing

Since 1925 Dr. Clair V. Mann has been studying aptitudes for engineering. Among the aptitudes studied is "power to visualize." By psychologists and engineering writers, according to Professor Mann, this has been designated variously as the "faculty," "power," "quality," "capacity," or "special aptitude" to visualize—"see with the mind's eye."

Dr. Mann has collected from one hundred most eminent engineers of the United States opinion as to value of this quality to engineers. Answers have been carefully analyzed and tabulations made. Consensus of opinion is that "power to visualize" is indispensable to the designing engineer who accomplishes more than routine work and that most engineers found capable of designing works of magnitude have seemed to possess this quality in high degree. Most engineers who submitted replies indicate that in design and construction they utilize this ability, conceiving first the work as a whole, then gradually extending "vision" to all details.

Literature of engineering relating to qualifications of engineers and engineering students is certainly full of statements that imagination, power to visualize, power to "see with the mind's eye" structures that do not exist, are qualities which the engineer must possess if he is to succeed.

Diverse opinion exists as to whether this quality is purely "native" (and so incapable of development or training) or whether it can be considerably developed, and should be so developed in the *engineering student.* Opinion relative to types of courses which develop the ability indicate that, of all subjects taught in the engineering college, descriptive geometry, in a peculiar way, tends to develop this quality. Writers of textbooks in descriptive geometry, practically without exception, introduce their subject with the statement that descriptive geometry definitely detects and develops this quality.

Readers should note carefully that the above is a summation of opinion. The real *study* of this quality is being conducted in Professor Mann's laboratory and in classrooms of his department at the Missouri School of Mines. Here tests are being devised which definitely *measure* this quality. The consensus of opinion referred to above seems to indicate that engineers do not know of methods whereby power to visualize may be *definitely, qualitatively* or *quantitively* measured. Measures of both types are being used in this study and intensive research is in progress which will ultimately supply *numbers* of measures of this kind.

THE PLACE OF SOLID GEOMETRY IN THE MATHEMATICS CURRICULUM AND SOME METHODS OF PRESENTING THE SUBJECT *

By LOUIS O'SHAUGHNESSY

Virginia Polytechnic Institute

It was with pleasure that I undertook to prepare a paper with which to open the discussion concerning "the place of solid geometry in the mathematics curriculum and some methods of presenting the subject."

There is a general impression that there is considerable opposition to having mathematics, particularly solid geometry, in all curricula.

So may we not consider first the question: To what extent is mathematical training necessary in general education?

The need of mathematically-minded men in all the walks of life is becoming more and more evident. In politics, in religion, in law and in general business, we encounter only too often, very striking instances in which logically directed reasoning from accurate premises to a sound conclusion is almost completely lacking.

The propaganda method of attaining one's desires has supplanted pure reason, to a very great extent, and has tended to weaken our social, religious, legal and economic structures.

The modern social philosophy that individual responsibility does not exist, is tending to weaken organized society; the many isms of religion are diverting the people from a sound religious philosophy; the devious legal technicalities are affecting the standing of our courts; while, under a peculiar, new economic philosophy we have been living in an economic haze for a decade.

We were told that we were in a new financial era in which the old laws of economics no longer held—we were in an era in which the more we produced the more we could sell at a greater profit, so as to produce still more and sell at a still greater profit. Such a statement seems ridiculous and yet it is not one whit overdrawn. This may be called perpetual motion as applied to business.

However, last October we learned that there is nothing new; that our financial leaders had reasoned only for the immediate present with no eye at all to the future; and, finally, when the break came, their explanations were, if possible, worse than was their original advice.

* Presented at the 38th Annual Meeting, S. P. E. E., Montreal, Canada, June 26–28, 1930.

Time forbids citing almost innumerable instances in support of the above statements.

Furthermore, in the colleges, doubtless most of you have observed the attitude of many arts or finance students who come into a mathematics class. They are inclined to argue about the soundness of mathematical reasoning and conclusions and seem to wonder how an exact science can exist—in fact the conclusions reached are so positive that they are astonished that there is no room for argument. I have had many interesting and instructive instances of the above to come under my observation.

I know that I am speaking to a group favorable to having mathematics in educational curricula, but I wish to say that from direct contacts with modern business I am of the opinion that mathematically trained men are very badly needed; and, that because of this need, mathematics should be included in all educational curricula.

After I had written the above I received a copy of the addresses delivered before the Association of Virginia Colleges, last February. May I quote from a paper by Dean Page, of the University of Virginia, on Mathematics as a subject prescribed for college graduation? "All clear and accurate thinking is done along logical lines. Professor Cassius Jackson Keyser, of Columbia University, a profound Mathematician and Philosopher, says that 'Symbolic Logic is Mathematics, Mathematics is Symbolic Logic, they twain are one. This is one of the greatest discoveries of our age.'

"All logical thinking can be expressed through Symbolic Logic, i.e., Mathematically. Hence, all clear and accurate thinking may be said to be along Mathematical lines, although the thinker is generally unconscious of the fact." "If Professor Keyser is right that Logic and Mathematics are one (and I think he is right) then I see no reason to be surprised at the leading rôle played by Mathematics in modern Physics or in any other subject, if the latter is to be developed logically."

"Now some of my friends in educational psychology tell me that the mastery of one subject does not assist in the study of another, except insofar as the subjects overlap or are 'correlated.' Therefore, since it is true that the accurate thinking of the world is (consciously or unconsciously on the part of the thinker) shaped in mathematical moulds, and since the study of other subjects helps little in preparing these moulds, it would seem that to eliminate or reduce further the study of Mathematics in school and college would strike a sad blow at accurate thinking."

These quotations help to confirm my opinion as to the need of Mathematics in all curricula.

Our second question is: What mathematical subjects should be taught?

I believe it may be assumed that one should be trained in both geometry and algebra, that is, in the two types of reasoning inherent in these two subjects.

Certainly no education in mathematics could omit geometry entirely, and, if geometry is worth teaching at all, why should we confine our study to space of two dimensions—since our entire existence and all of our experiences are in space of three dimensions? Is it not necessary that one should not be a "flat lander," but should be thoroughly acquainted with three-dimensional space and the ways and methods for measuring and determining the relative importance of different bodies in space?

Solid geometry is the first subject to appeal to the powers of visualization and, with its complementary subject descriptive geometry, is most helpful in mental development. Their counterparts in analysis are oral or mental arithmetic and oral or mental algebra.

Geometrical reasoning causes one to hold to the original premises and reason straight forward to a sound conclusion—or at least to a conclusion not at variance with the original hypotheses.

The weakness of many sciences, which are in a process of growth or development, is that the whole groundwork of the science is uncertain and the tendency to make a debating society out of any meeting in which the subject is discussed leads to loose reasoning and to a very changeable kind of philosophy.

Of course, the frontiers of mathematics are not stationary—but the ground work of the science is so well fixed that no other science can take its place in the accuracy of its reasoning.

It is these elements of consistency, certainty, cogency and clearness which make mathematical training so valuable and no subject in mathematics has these elements to a greater extent than has solid geometry.

The importance of solid geometry in the engineering curricula is generally admitted. It is extremely important as a prerequisite for spherical trigonometry, solid analytical geometry and for the applications of the calculus to surfaces and volumes. In teaching mechanics we should be entirely lost if our students were not acquainted with the mathematical concepts and laws involved in the measurement of solids.

In the college with which I happen to be connected we do not require solid geometry for entrance to the college of agriculture or, in general, to the arts college; however, we are working toward a goal and I hope we shall be able very soon to make it a uniform requirement for entrance to the Institute.

When a student from either of the other colleges happens to be in a mathematics class or a mechanics class in the school of engineering we notice his need of solid geometry, spherical trigonometry and solid analytics because his whole field of study has been circumscribed or limited to space of two dimensions and his ability to visualize, to say nothing of his ability to determine the magnitude of objects in three-space, is almost entirely lacking.

So it would seem that if we leave solid geometry out of the curriculum we shall not only deprive the student of its visualizing processes which aid in mental development but shall from the very necessities of the situation confine his entire mathematical viewpoint to space of two dimensions.

I have studied the entrance requirements of some 96 colleges and universities and I find that practically all engineering schools require solid geometry for entrance, while it is not required for entrance by many of the other schools. The results of that study show that of 70 schools with engineering, 57 require solid geometry for entrance and of 26 schools without engineering, only 6 require solid geometry for entrance. Is it not about time that these conditions were remedied?

I have already referred to the necessity of having solid geometry in the mathematics curriculum—for it seems to be the foundation for descriptive geometry, solid analytics, the calculus as applied to solids and for all subjects of mathematics which have anything to do with space of three dimensions.

It may seem clearer to say that there appears to be no logical reason for omitting the subject from the curriculum—and thus creating an unnecessary gap in the regular development of mathematical training.

A study of entrance requirements made by Dr. J. E. Williams, dean of the college at the Virginia Polytechnic Institute, shows that the ideal entrance requirements for engineers are: four units in English, two units in algebra, one and one half units in geometry including solid geometry, one unit in history, one unit in physics, one unit in chemistry, one unit in drawing and four and one half units in other topics. Students with these requirements satisfied passed 91 per cent. of their required quarter credit hours. Those with solid geometry to their credit passed 81 per cent. of their required credit hours while those without credit in solid geometry passed only 60 per cent. of their required credit hours. These results were obtained by studying the records of 214 engineering freshmen. The total credit hours required were 3,852. This study shows rather clearly the value of solid geometry as an entrance requirement to engineering curricula.

The question as to the time the subject should be taught depends upon the general relations or understanding between the high schools and the colleges in their attempt to articulate their courses in mathematics and to make the progress continuous from high school to college.

For engineering students solid geometry should be taught in the high school either in the junior year or the senior year, while for arts colleges, if absolutely necessary, it may be deferred until the freshmen year in college, although even in this case it is much better to have it completed before entering college. Many mathematics teachers are of the opinion that during the last half-year in high school the prospective college students should have a thorough review in algebra and geometry, and nearly all would be glad if solid geometry were completed before the student enters college.

I am almost old-fashioned enough to believe that it is rather difficult to tell an experienced teacher just how to present a subject. However, it seems to me that in teaching solid geometry we should use all available methods: lectures, board work, written exercises, practical problems, original propositions, demonstrations by means of models and general discussions; viewing the subject first from the standpoint of its subdivisions or units and then as a whole. It is surprising how we may "boil down" the entire subject and thus give the student a general view of the work both from the standpoint of its value in mental development and from its value as a practical help in everyday life.

I have just reviewed a text which divides the subject into lines and planes, surfaces and sections of surfaces, areas of surfaces, volumes and polyhedral angles, and spherical polygons. This is a modern text written by a gentleman who specializes in methods of teaching mathematics.

The text I used first, contains the divisions—lines and planes, polyhedrons, and the cylinder, the cone and the sphere. The text which I used some fifteen or twenty years ago had divisions of lines and planes, polyhedrons and cylinders and cones and the sphere; while a more recent text divides the subject into lines and planes, polyhedrons, the cylinder and cone, and the sphere. The four books referred to are fairly representative of the years 1900, 1910, 1920 and 1930, and I believe that any one of them could very well be made the basis for the outline of a course in solid geometry.

I am afraid that there is no easy road to a knowledge of solid geometry—if there were it would lose almost one half of its value. The development of the intellect is very much like the development of the physical man—by using continually the mind so as to exercise it not to anesthetize it, it grows and increases in power.

However, if the ultra-practical view be taken, then it is sufficient to learn mechanically and in the imitative way. I am certain that none of us believes that the latter is real education.

In agreement with the views just stated I quote from the report of the committee on geometry syllabus which had Professors D. E. Smith, H. L. Rietz, and E. R. Hedrick as chairmen of the three sub-divisions.

"1. Geometry is taught because of the pleasure and profit it gives.

"2. Closely connected with the logical element is the training in accurate and precise thought and expression and the mental experience and contact with exact truth.

"3. The study of geometry cultivates space intuition and an appreciation of and control over forms existing in the material world which can be secured by no other topic in the high school curriculum.

"4. The value of the application of geometry to mensuration . . . is well recognized by all teachers.

"5. Solid geometry is valuable because it cultivates the powers of visualizing solid forms from flat drawings without studying descriptive geometry."

I have felt that the idea of motion is useful in geometry—motion of the point generating the curve, the motion of the curve generating the surface and the motion of the surface generating the solid. The above committee agrees with this idea.

So, from the standpoint of practical usefulness, and also from that of educational value, solid geometry deserves a place in our mathematics curriculum—while the methods of presenting it should be: first, as to logical sequence of theorems, then from the standpoint of the unit, and finally, from that of the subject as a whole. I am a thorough believer in the value of the subject and I shall certainly regret deeply the day when it shall be dropped from any more curricula.

NEW MEMBERS

BROWN, ARTHUR S., Instructor in Electrical Engineering, University of Arkansas, Fayetteville, Ark. C. L. Farrar, W. R. Spencer.

COSANDEY, CHARLES J., Instructor in Electrical Engineering and Mathematics, Duluth Junior College, Duluth, Minn. E. F. Peterson, F. L. Bishop.

CUMMINGS, HAROLD N., Professor of Civil Engineering, Newark College of Engineering, Newark, N. J. J. C. Peet, J. A. Brooks.

DOUGLAS, EARL C., Instructor in Engineering, Joliet Junior College, Joliet, Ill. H. H. Jordan, E. P. Hoelscher.

FINCH, JOHN W., Dean, Idaho School of Mines, University of Idaho, Moscow, Ida. Ivan C. Crawford, J. Hugo Johnson.

FISHER, HILBERT A., Associate Professor of Mathematics, North Carolina State College, Raleigh, N. Car. John M. Foster, R. P. Kolb.

GARDNER, ROBERT A., Instructor in Civil Engineering, Bucknell University, Lewisburg, Pa. D. M. Griffith, W. D. Garman.

GILTNER, CARL W., Laboratory Instructor in Mechanical Engineering, Purdue University, Lafayette, Ind. L. V. Ludy, J. D. Hoffman.

GODEKE, HARRY F., Professor of Mechanical Engineering, Texas Technological College, Lubbock, Texas. J. H. Murdough, W. J. Miller.

GRUMMANN, HERBERT R., Instructor in Mathematics, Washington University, St. Louis, Mo. A. S. Langsdorf, E. O. Sweetser.

HOUGEN, OLAF A., Associate Professor of Chemical Engineering, University of Wisconsin, Madison, Wis. O. L. Kowalke, O. P. Watts.

HOY, ELVIN A., Instructor in Mathematics and Engineering Drawing, University of Hawaii, Honolulu, T. H. C. B. Andrews, A. R. Keller.

MILLER, WILLIAM T., Instructor in Mechanical Engineering, Purdue University, Lafayette, Ind. G. W. Munro, J. A. Sauers.

PAUSTIAN, RAYMOND G., Instructor in Civil Engineering, Iowa State College, Ames, Iowa. A. H. Fuller, Frank Kerekes.

ROLOFF, WALTER E., Professor of Economics, Colorado School of Mines, Golden, Colo. R. A. Baxter, J. R. Morgan.

SABBAGH, ELIAS M., Instructor in Electrical Engineering, Purdue University, Lafayette, Ind. C. Francis Harding, D. D. Ewing.

STILL, ALFRED, Professor of Electrical Engineering, Purdue University, Lafayette, Ind. C. Francis Harding, D. D. Ewing.

VAUGHAN, EVAN W., Instructor in Engineering Drawing, Case School of Applied Science, Cleveland, Ohio. W. E. Nudd, C. W. Coppersmith.

WELLMAN, B. LEIGHTON, Instructor in Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. J. H. Whenman, K. G. Merriam.

DISCUSSION: CAN THE ENGINEERING STUDENT BE TAUGHT TO MANAGE MEN?

Professor Smith is to be commended for bringing to the attention of engineers the fact that there is a demand for men of executive as well as technical ability.

Under the leadership of Dean Hitchcock, we have realized this fact at Ohio State University and during the last five years have been giving a course which corresponds very largely to Professor Smith's outline. In addition, however, to the subjects that are brought up in this outline, we find that the teaching of time and motion study offers special opportunity for introducing the human equations. We also find that the course in "The Laws of Engineering Management," which Mr. L. P. Alford introduced in his book, gives still further opportunity to bring human problems to the attention of our students.

With the close tie-up between our shops and our Industrial Engineering courses there is no question but the engineering student can be taught to manage men. We have done this and are very satisfied with the results.

JOHN YOUNGER.

PHOTOGRAPHS OF PROMINENT ENGINEERS

The American Society of Mechanical Engineers have photographs of 49 past-presidents and 72 honorary members which they can supply at a price of 75c a print, 6 11/16 × 9 1/4 in size, or $75 for the entire set of 121 prints. They suggest that these pictures can be suitably mounted and framed by members of the Student Engineering societies. Possibly the other national engineering societies have lists of their most prominent members whose photographs they can supply in usable size and at reasonable price. It is thought that such photographs of prominent and successful engineers have both an educational and inspirational value to the engineering student.

COLLEGE NOTES

The School of Engineering, **George Washington University,** is now occupying a new Mechanical Laboratory which was erected during the summer months, housing the Mechanical, Materials Testing, Hydraulic, and Concrete Laboratories, in addition to the Drafting Rooms, a Computing Room, and an Instrument Room.

An unusual feature of the new Laboratory is the adoption of open balconies overlooking the main laboratory floor for use as drawing rooms. The indirect lighting system has been used throughout the building.

Dean John R. Lapham is enjoying his sabbatical leave and is following special research work in the field of Sanitary Engineering at Johns Hopkins University. Professor Arthur F. Johnson is officiating as Acting Dean during his absence.

Mr. Max A. Lett, who recently received his M.S. degree in M.E. at Iowa State College has been appointed as Instructor in the Mechanical Engineering Department of the School of Engineering.

The School of Engineering is offering a new course leading to the degree of B.S. in Engineering. The purpose of the Senior Year of this course, which consists entirely of elective subjects, is to allow exceptional students to center their attention upon a group of subjects in which they have special interest. Students desiring Patent Law may satisfy the requirements of this elective year by completing the first year of the regular course in the George Washington Law School.

The **Harvard Engineering School** is offering this year a new course on vibration problems. This subject is growing in importance in the design of high-speed machinery, but it has been neglected in most American engineering schools, although well established in the schools of Europe. The technical literature on mechanical vibration is very extensive in Germany and to a lesser extent in England, but American engineers have been interested in vibration problems only for a little over ten years. Campbell's famous investigation of turbine disc vibration made for the General Electric Company, the work of Akimoff on balancing, and the work of Timoshenko and Soderberg at the Westinghouse Company are all modern developments which have their roots in European literature. Lewis's paper on "Torsional Vibrations in Diesel Engines" appeared only five years ago. The problems are not limited to the design of machines but arise also in the vibrations of high buildings, ships, and aircraft.

This movement on the part of the Harvard Engineering School is intended to acquaint its graduates with an understanding of the physical and mathematical basis of mechanical vibration and with the literature so that they may handle the problems related to the ever increasing size, speed and power now developing in the engineering world.

The instruction of the course is being given by outside lecturers, Messrs. J. Ormondroyd and A. L. Kimball, the general direction of the course being under Professor Arthur E. Norton of the School.

Massachusetts Institute of Technology.—With this school year the Institute starts upon a new and unusual administrative plan. Dr. Samuel W. Stratton, formerly President, becomes Chairman of the Corporation, and Dr. Karl T. Compton, formerly Chairman of the Department of Physics at Princeton University, takes up the office of President of the Institute. Under the leadership of these two men of science the Institute can pursue more effectively than ever its program of graduate and undergraduate instruction in engineering and sciences.

A new dormitory, offering housing facilities for 210 students, was ready for occupancy this fall. This building forms the second unit of the new dormitory quadrangle.

The registration has increased about 200 this year, bringing the total number of students above the 3,200 mark.

Professor Paul Scherrer of the Technische Hochschule, Zurich, Switzerland, is at the Institute this term giving a series of experimental lectures on "Various Phases of Atomic Theory."

Professor J. A. Schouten of the Technische Hoogeschool, Delft, Holland, visiting professor of the Rockefeller Foundation, is lecturing at the Institute this term on "The Geometry of Linear Displacements."

Swarthmore College.—Howard M. Jenkins, Asistant Professor of Electrical Engineering and Industrial Management, returned to Swarthmore this fall after a year's leave, which he spent with the Arthur Andersen Company of Chicago. Dwight K. Alpern, who substituted for Professor Jenkins in 1929–30, has a fellowship at Columbia University and is studying under Dr. Fink. Otherwise our teaching staff remains the same.

A new Lycoming and a six-cylinder Buick motor make distinct additions to the Mechanical Laboratories, while the acquisition of photomicroscopic equipment marks the enthusiastic beginning of our metallography courses.

October 25th was the annual homecoming occasion for Swarthmore alumni engineers, and was celebrated by inspection trips

through the new Clothier Memorial Auditorium and through our shops and laboratories. A dinner meeting was addressed by President Frank Aydelotte and Professor Jenkins.

Swarthmore is looking forward to the annual student meeting of the Philadelphia Section of the American Institute of Electrical Engineers which is to be held here next spring.

SECTIONS AND BRANCHES

Colorado School of Mines Branch.—A Branch of the Society for the Promotion of Engineering Education was organized at the Colorado School of Mines on October 22, 1930, with a membership of eleven. The following officers were elected: President, R. A. Baxter; Vice President, I. A. Palmer; Secretary and Treasurer, G. W. Salzer.

At the first meeting a paper was given by Dr. George W. Salzer on "Descriptive Geometry as Applied to Engineering Education."

The second meeting was held November 12, and a paper was given by Professor I. A. Palmer on "Engineering Education."

It is planned to have four more meetings during the school year.

Kansas-Nebraska Section.—The Kansas University group welcomed the visitors on November 7 at a 6 o'clock dinner at the Presbyterian Church. This afforded an excellent opportunity for introductions and the renewal of acquaintances.

The session at Marvin Hall Auditorium began at 8:00 P.M. with President J. P. Calderwood presiding. There were 80 present. In introducing Chancellor Lindley of Kansas University, President Calderwood called attention to the fact that this was the first occasion on which the executive head of the colleges represented had appeared as a speaker.

Chancellor Lindley welcomed the visitors to Kansas University and evidenced his interest in the work of the engineer and the teacher of engineering subjects.

President Calderwood then introduced Professor E. D. Hay, Kansas University, Chairman of the Program Committee.

Professor F. E. Johnson of Iowa State College, discussed "Development of Personnel Work in Engineering Schools," relating experiences of his own college days that indicated decided lack of interest of faculty members in his future. This in contrast to recently developed systems of supervision and guidance. Professor Johnson outlined the plan in use at Iowa State College and

also read extracts from letters from industrial employers commenting on various personnel systems. These seemed to indicate the need of further development. Professor Johnson expressed the idea that the faculty owes it to students to advise them of the conditions and requirements they will encounter in industrial activities.

Professor R. G. Kloeffler, Kansas State Agricultural College, presented a paper "A Market Analysis of Electrical Engineering Graduates." Data and graphs were shown as lantern slides. Trends during past years and forecasts of developments in various branches of its electrical industry were used in estimating the number of graduates that can be absorbed by that industry during the next five years.

Professor J. P. Colbert, University of Nebraska, spoke on "Organization of Personnel Work, How to Make it Effective." Professor Colbert dealt principally with the problems of supervision and guidance of the student during his first year. The faculty members must all be of service and assist the personnel officer.

Dean O. J. Ferguson responded briefly to a call for discussion. He mentioned the use of tests devised by psychologists which, with recent revisions are helpful in making classifications. Good personnel work must be based largely on personal acquaintance. Avoid making the system too mechanical.

President Calderwood appointed as a nominating committee

Professor F. A. Russell, Kansas University,
Professor L. E. Conrad, Kans. State Agr'l College,
Dean O. J. Ferguson, University of Nebraska.

Speaking on the topic "The New Telescope at Kansas University," Mr. William Pitt of Kansas City, Missouri, gave an interesting description of the method followed in grinding the lens of pyrex glass for this telescope. In the rough this lens was about 27 inches in diameter and 4½ inches thick.

Following Mr· Pitt's talk the program for the day was concluded by an opportunity for those present to visit the observatory and inspect the telescope in which the finished lens is to be mounted. Many of those present looked forward to a future visit to the completed observatory.

Saturday Morning, November 8, 1930

Meeting called to order at 9:20 A.M in Marvin Hall Auditorium by President Calderwood. Thirty-five were present.

"The S. P. E. E. Summer Session at Yale" was reported on in detail by Professors M. W. Furr and L. E. Conrad, Kansas State

Agricultural College. Both speakers felt that attendance at this summer meeting had been of definite value. The length of time the men were together permitted better acquaintance and afforded ample opportunity and time for real discussion of many problems.

"The S. P. E. E. Summer Session at Pittsburgh." Professor F. A. Smutz, Kansas State Agricultural College, attended this meeting for teachers of Engineering, Drawing and Descriptive Geometry and quoted from the addresses of several of the speakers at the Session. Professor George J. Hood, Kansas University, also reported briefly on the same meeting. Both speakers expressed appreciation of the hospitality and courtesies shown them by Carnegie Institute of Technology.

"The 38th Annual Meeting of S. P. E. E. at Montreal." The reports of this meeting by Professor J. W. Haney, University of Nebraska, and Professor R. M. Kerchner, Kansas State Agricultural College, brought to us a description of some of the events of particular interest. It was evident from the remarks of these speakers that their attendance at the Montreal Meeting had given them a better understanding of the work and objectives of S. P. E. E.

The business session then followed.

Professor F. A. Russell reported for the Nominating Committee submitting the following recommendations:

For President, J. W. Haney, Univ. of Nebraska,
For Secretary, Robt. Warner, Kansas Univ.
For Chairman Program Committee, O. D. Hunt, Kans. State Agr'l College.

The report of the committee was adopted unanimously and these men declared elected for the ensuing year.

The meeting then adjourned for inspection of the Wind Tunnel in process of construction under the West Stadium.

The group re-assembled at 12:15 P.M. at the University Club, the Kansas University engineering faculty again acting as hosts for luncheon.

President Calderwood presided in the short after-dinner program. Responses by Dean O. J. Ferguson and Dean A. R. Seaton expressed the appreciation of the visitors for the hospitality extended by the engineering staff of Kansas University. Dean Seaton also extended an invitation to the Kansas-Nebraska Section to hold the 1931 meeting at Manhattan, Kansas.

Professor F. A. Russell responded for Dean Shaad expressing the pleasure of the Kansas University group that the number in attendance appeared to have broken previous records.

President Calderwood was particularly appreciative of the work of the Program Committee and of those having charge of the local arrangements.

Final adjournment came at 1:30 P.M.

E. E. BRACKETT,
Secretary

Minnesota Chapter.—The first meeting of the Minnesota Chapter of the Society for the Promotion of Engineering Education for the year 1930 was held Thursday, November 20th. Dinner was served at 6:30 P.M. at the Campus Club. Two speakers, Professor W. E. Brooke of the University of Minnesota and Mr. C. N. Stokes of University High School, addressed the Society on different phases of the subject "The Preparation in Mathematics of Freshmen Entering the College of Engineering and Architecture." The fifty members and guests who were present gave evidence of their interest in this timely subject by participating in a lively discussion following the two addresses. Indeed, had it not been for the timely intervention of President Bryant, it is possible the discussion would have extended "So, far, far, into the night."

The Nominating Committee consisting of Professors Brooke, chairman, Cutler and C. A. Mann, presented the following slate of new officers:

President, George C. Priester, Mathematics,
Secretary and Treasurer, Charles F. Shoop, Mechanical,
Chairman Program Committee, Elmer W. Johnson, Electrical.

Upon the motion of Professor Kirchner, the Secretary was instructed to cast a unanimous ballot for these men for the new officers. The meeting then adjourned.

RALPH E. MONTONNA,
Secretary.

NECROLOGY

BROTHER AZARIAS MICHAEL

Brother Azarias Michael was born in Kinkora, Prince Edward Island, on June 22, 1877. He was ordained in 1894 at St. Joseph's Normal Institute, Amawalk, N. Y. He began teaching in old St. Mary's lower East Side, in 1896, and later was transferred to La Salle Academy where he taught until 1901. Brother Azarias also taught in Syracuse and Troy. In 1910 he was sent to De LaSalle Institute, New York City, to take charge of the enginering courses. He studied at Harvard University. He was assigned to Manhattan College where he taught for eighteen years, the last ten of which he was Dean of the School of Engineering. Brother Azarias died suddenly September 17, 1930. He has been a member of this Society since 1928.

BOOK REVIEWS

Foundations for Human Engineering. By CHARLES R. GOW. Edited by F. ALEXANDER MAGOUN. Macmillan Co. New York, 1930.

"Foundations for Human Engineering," by Charles R. Gow, Professor of Humanics at Massachusetts Institute of Technology, is an edited series of lectures covering the scope of the subject of humanics as applied to the engineering graduate. It is an attempt to fit the graduating engineer to cope with some of the problems, personal rather than technical, which he will encounter during his first few years. Unlike most attempts of the kind, this book does not ladle out advice without any attempt at justification. The most interesting and probably the larger portion of the book is taken up in describing actual experiences, and the morals and precepts are left to the reader. The first chapter is by William Emery Nickerson, donor of the course of Humanics at M. I. T. It is like the rest of the book a helpful list of mistakes possible to the graduate. Every engineering graduate can find much to interest and help him by reading this text.

F. L. B., JR.

Elements of Mechanisms. SCHWAMB, MERRILL AND JAMES. John Wiley and Sons. 372 Pages. Fourth Edition.

This book is much larger than the usual text book that covers mechanisms only. It consequently devotes much more space to the

part on belts, gear trams, gears, link work and straight line motions and is more complete on these subjects than most text books. The book limits itself to mechanisms almost entirely and does not give much space to the finding of accelerations, velocities, and forces in machines.

The addition of problems at the end of the chapters should make the book more valuable for class work. It has many illustrative problems and an excellent list of problems at the end. Only minor changes were made in this edition.

E. K.

Heat Engines. By CHAS N. CROSS. 607 pp. Macmillan. 1930. $6.00.

In spite of some minor shortcomings this book measures up to the high standard of excellence of the previous volumes of the Macmillan Engineering Science Series. The chapters on Steam Turbines and Internal Combustion Engines are particularly valuable. Much valuable numerical data is included in the numerous tables in the text. Short historical sketches of the development of the various devices serve to give the student a good perspective, and to appreciate at their proper value the services of the pioneers as well as the more recent workers in the field of Heat Engineering.

The author does not show in any high degree the power of condensing his discussions into small compass. As a result, some parts of the book appear rather diffuse, and some topics are treated rather sketchily in order to keep the size of the book within reasonable limits. In some instances the author has merely asserted laws which are easily susceptible of proof, and in a few cases he has been led into making statements of rather questionable accuracy. It should be added that none of these errors are of serious importance.

On the whole the book will be a very welcome addition to the literature of the subject.

J. A. D.

PERSONAL RELATIONS OF TEACHERS WITH NATIONAL ENGINEERING SOCIETIES*

By CALVIN W. RICE, Secretary,
The American Society of Mechanical Engineers

The object of all education is to develop citizens—citizens who are to be lofty-minded, unselfish and devoted to the welfare of the community. Technical training is secondary.

After the masterful addresses of yesterday and the important discussions last evening and this morning, I feel very humble. I join General Mitchell in the statement that he should be the last speaker of the morning because I think his point, namely, the relation of the teacher to the community is the most important of all.

President Hoover recently in greeting the Boy Scouts said we must add to the three R's one more R—Responsibility to the community.

Last month on the occasion of the dedication of the new home of the New York County Lawyers Association, Chief Justice Hughes said that "*expert public service* had given a peculiar dignity to the profession of the law." William Nelson Cromwell, on this occasion, contributed $150,000 to establish the Law Foundation. Of the nine objects of this Foundation, four (abbreviated) are:

First, Elevation of the Standards of Admission to the Bar and the Practice of the Profession.

Second, Cultivation of the Highest Standards of Professional Ethics.

Third, Encouragement of Coöperative Fellowship for the Good of the Profession.

Fourth, The Promotion of Justice as the Bulwark of National Life.

Dr. Millikan and others have made similar statements.

Dean Anthony was quoted by President Rees as having stressed that it is the manner of teaching. Professor Barker spoke of the importance of producing "men." If Dean Anthony were here, no doubt he would state that of the 6,700 cards returned in answer to a questionnaire sent to leaders of industry 85 per cent. placed Character as the most essential quality. In the votes this year among certain college students, it is interesting to note in the

* Presented at the annual meeting of the Society for the Promotion of Engineering Education, Montreal, Friday, June 27, 1930.

answers to various questions, facetious as well as serious, that there again the student named Character as the most desirable quality.

Professor Kinsloe spoke of the unit system at Harvard, Yale and other institutions and it is obvious that the leader in those unit houses must be a man of character.

In order, therefore, to maintain the quality of the members of the Engineering profession and of the Engineering societies, the most intimate coöperation on the part of the members of the teaching profession is solicited and we must commence at the very foundation. And I therefore propose that in the selection of all qualified candidates for teachers of any subject you select men of character and of sympathy. To illustrate what I mean, Dean Bishop told of an incident of the visit from Dr. Mayo of Rochester who was the Commencement speaker. When Dr. Mayo went to his room in the hotel, he found the corridor filled with persons seeking to consult him. When he went to his car to go to the University, one person succeeded in reaching him and although about to go to the Commencement address he nevertheless, because of his great feeling for humanity, asked the person to step into the car and to undress, Dr. Mayo there diagnosed the patient's malady and prescribed.

To go now to the specific relationships of members of the teaching profession, to the professional engineering societies, I will state eight points that to me are important:

1. In the United States we have the concept that each person is to develop himself to the utmost and at the same time develop the greatest capacity for coöperation.

In every suggestion I make, coöperation is involved.

An individual can contribute more to his profession through an organization than separately and outside of an organization. Therefore, every teacher should be a member of the S. P. E. E., and as soon as possible he should join the Engineering Society which best represents his specialty.

It is entirely appropriate to bring out incidentally that by common consent the approved means by which a professional man may bring his attainments to public notice is through participation in the activities of the organization of his profession. In this connection, I am very happy to give testimony to the contribution which has already been made by the members of the teaching profession to the work of the engineering societies. In the four national engineering societies, the statistics show that on the average 16 per cent. of the presidents have been members of the teaching profession. In committee work one finds that 7½ per cent. of the committee men are teachers.

As a collateral advantage, the mutual benefits are important in the contacts that are made. If any one should ask a graduate after he had been out of college a few years what were the benefits he had derived from a college education it is doubtful if the graduate could answer quickly and it is also doubtful if he would say technical equipment. In all probability the reply would be "contacts." Contacts with the teachers and with one's associates. Therefore, these contacts of the teachers with men of affairs of the world, because it is obvious that committee men are the men having the finest minds and the most up to date knowledge, in turn give a teacher a convincing manner and an atmosphere of authority in the classroom. Conversely, the men in actual life work become acquainted with the work of the teaching profession and will develop, we will trust, a sense of obligation to share in the work of preparing men for the profession of engineering.

2. *Research.*—In no one activity have the participation and coöperation of the two groups, the S. P. E. E. and the engineering societies, been more important than in research. Still greater effort can be made along the line of making industry research-minded, emphasizing that if our nation is to maintain its prestige still further research must be continuously undertaken.

As an example of the benefit of research in the particular manner on which I wish to place the most emphasis namely, for the *common welfare,* I wish to point to smoke abatement. In the several colleges, more recently Stevens Institute of Technology, a Chair has been founded on that subject and one of the recognized experts, Colonel Whitlock of Cleveland, who has developed his authoritative position in the United States through activities in a professional society has now been given a chair for a two-year study and undoubtedly will give special attention to the problem in the Metropolitan District of New York. President Davis of Stevens Institute has been serving on the smoke abatement committee of the city upon the nomination of a national society.

Other examples of this type of success can be given, illustrating the benefit to the community by research and coöperation. I will give one more example, namely, that of International coöperation in research. Researches here followed by conferences abroad have been held for several years on the determination of steam tables, a subject of great importance to the power industry. Members of the staffs of two colleges and the Bureau of Standards have coöperated under the direction of a national society and with corresponding committees and individuals abroad. Representatives from these colleges, the Bureau of Standards and the National Society have regularly gone abroad and are now abroad with expenses paid from funds secured by the Committee.

I wish to especially compliment many that are in this room who have made the University with which they are connected of special service to the people of their respective States.

3. *Travel Fellowships and Lecturers.*—Several of the societies have travel fellowships and members of the teaching staff of colleges have been awarded these scholarships and conversely some of the travel scholars of colleges have been assisted by the engineering societies in making contacts abroad. This should be still further encouraged. It brings specific knowledge to the United States for the benefit of our nation as in the case of the Freeman Travel Scholarship, securing information for hydraulic laboratories resulting, as you all know, in an appropriation from the present Congress of $350,000 for the establishment of a hydraulic laboratory under the direction of the Bureau of Standards. It also broadens the view of teachers and in turn enables them to be more authoritative in the classroom and to give out an atmosphere of goodwill and tolerance in our world relations.

The visit of a teacher abroad in either direction is a stimulus not only to the students but to the faculty itself and addresses before colleges and engineering societies can often be arranged.

4. *Attendance at Conventions.*—I wish to emphasize to the colleges the desirability of recognizing the importance of appropriations which will provide for official representation with mileage to meetings of certain organizations. This can be systematically arranged so that membership in the leading bodies of the world are apportioned among the faculty. In this connection it should be brought out that the teacher through his familiarity with the work of the society incidentally becomes the natural advocate of the society to the student so that the latter seeks membership as early as possible in life.

5. *Vocational Advisors.*—I recommend developing still further vocational advisors in each of the branches of engineering and that they contain (*a*) representatives of the alumni, and (*b*) representatives of the societies.

6. *Adjustments of the Curricula.*—The teaching profession of its own initiative has taken the lead and at no time has industry or the engineering societies been more alert than the teaching profession to the necessity for readjustment. The research in this respect has been extraordinarily well conducted by this body but in a natural manner the societies may be invited by you to appoint committees to study continually the subject and to make suggestions for your consideration in the spirit that they have an obligation to perform in this respect.

7. *Group Consciousness.*—The teaching profession and the engineering societies have a great responsibility to develop group

consciousness in the engineering profession. There is the tendency in the specialization in the college, continued in after life by the societies, to put over-emphasis on the specialties. There must be a definite process to counteract this attitude. It is essential for the whole concept of professional ideals and ethics. In the legal profession a man graduates in law and he never loses the concept that he is a member of the legal profession, regardless of his specialty. The same is true of the physician. Without in any way even appearing to suggest a change in the specialization either in the colleges or in the engineering societies I do emphasize the need of a greater degree of coöperation and frequent joint meetings and joint activities of the students in the several branches of engineering so that they may develop early in life the idea that they are members of one great profession.

8. *Professional Societies to be Regarded as a Post-Graduate Course.*—Education is continuous throughout life. Coöperation between the teachers and the societies should be so close that students are encouraged to progress naturally from the college to the engineering society and it is a mutual undertaking of both the society and the teacher to make men worthy of membership in the society on the one hand and to furnish the incentive to assist the teacher in his work of obtaining the greatest devotion while the student is in college.

To recapitulate

1. Every person is to develop himself to the utmost as an individual and at the same time to develop the greatest capacity for coöperation.
2. Research. Seek to make all industry research-minded.
3. Develop travel fellowships and interchange of lectures between nations.
4. According to some system encourage colleges to make appropriations for attendance at conventions.
5. Still further develop vocational advisors.
6. Invite the appointment of committees on curriculum.
7. Develop professional group consciousness of the engineering profession.
8. Develop intimate relationship between colleges and engineering societies, emphasizing that education is continuous throughout life.

To carry out the suggestions of the morning, I recommend the appointment of a committee and that all the papers of the session be referred to it. This committee, in turn, to invite the appointment of corresponding committees in each of the societies. The writer pledges the most cordial support and coöperation of the engineering societies.

INTRODUCTION TO THE PRACTICE OF ENGINEERING

By PHILIP S. BIEGLER

Dean, College of Engineering, University of Southern California

There has been a considerable interest of late in freshman courses for engineering students, and, at the risk of making suggestions that are not new to many of the members, I shall explain briefly the orientation course given at the University of Southern California which has been developed over a period of years and which, we believe, now has taken on fairly permanent form.

In former years all new students in the University were required to take a course in Orientation, but the engineering students, with the coöperation of members of the faculty, arranged, through the agency of the professional societies such as the A.I.E.E., for lectures and inspection trips quite apart from the university course in orientation. Upon the organization of the College of Engineering in 1928, one lecture period a week was set aside in the schedule for engineering lectures and student and faculty meetings, and as few classes as possible were scheduled for Friday afernoons also. An excellent program of lectures and trips was arranged for each semester, providing a lecturer for every other week and an afternoon trip for the alternate weeks. A typical program for one semester follows:

Lecture	Commander J. S. Evans, Chief Engineer, Battle Fleet, U. S. N.
Trip	U. S. S. California
Lecture	Mr. R. B. Stringfield, Chief Chemical Engineer, Goodyear Tire & Rubber Company of California
Trip	Goodyear Tire & Rubber Company of California
Lecture	Mr. A. P. Hill, Acoustical Engineer, Electrical Research Products, Inc.
Trip	Electrical Research Products, Inc., or Southern California Telephone Company
Lecture	Mr. T. E. Swigert, Engineer of Production, Shell Oil Company
Trip	Standard Gasoline Company plants
Lecture	Mr. R. J. C. Wood, Electrical Engineer, Southern California Edison Company
Trip	Hydroelectric plants of the Southern California Edison Company in Mill Creek Canyon, and Colton Cement Plant (week-end trip)
Lecture	Mr. G. J. Carroll, Manager, Consolidated Steel Corporation

Trip	Llewellyn plant, Consolidated Steel Corporation
Lecture	Mr. J. H. Kindelberger, Chief Engineer, Douglas Aircraft Corporation
Trip	Douglas Aircraft Corporation
Lecture	Professor D. M. Wilson, "Engineering in Porto Rico"

Such marked success attended this program that it was decided to introduce a definite course, one unit each semester, to be required of all beginning engineering students, and the University voluntarily withdrew the general orientation course as a requirement for engineering students.

The new course was called "Introduction to the Practice of Engineering," and the name indicates its purpose or objective. A very fine group of men responded to invitations to lecture and gave the students a valuable bird's-eye view of many fields of engineering activity. Where possible, inspection trips followed lectures in such a way as to illustrate the talk.

When this program became a credit course, the students were required to hand in reports of from four to five hundred words on the trips, and great care was taken to make it possible for them to get reliable information concerning the industry visited. Usually mimeographed sheets are prepared giving the principal data of interest concerning the plant or field to be visited, and an attempt is made to have a sufficient number of guides so that there will be one guide for every twelve or fifteen students. It has been found that the report requirement adds very substantially to the value of the program, because the students are thus "on their toes" to get all possible information during the inspection trip. The reports are also read and criticised by the instructors who have these students in freshman English.

In an industrial community such as Los Angeles and its suburbs, it is possible to carry out a four-year program of lectures and inspection trips without repetition, and we find that older students in considerable numbers attend both lectures and trips after they have completed the required two semesters.

The College of Engineering is made up of the divisions of Chemical, Civil, Electrical, General, Mechanical, and Petroleum Engineering, and during the course of the year the program contains material of interest to students in all these branches. Moreover, we encourage our speakers to give the students, in addition to the technical material presented in the lectures, something of the philosophy of life for a professional man.

It is our belief that we have developed a very successful orientation program for an urban university in the midst of widely diversified engineering activities.

A LIBERAL EDUCATION

By J. HUGO JOHNSON
Head, Dept. of Electrical Engineering, University of Idaho

Fifty years ago it was only the exceptional high school graduate who went to college. Even twenty-five years ago most parents considered that they had done well, indeed, to afford their children the advantages of a high school education. Now, the youth of the land feel abused if parents do not, in part or whole, help them to attend one of our numerous colleges or universities.

This unparalleled rise in attendance at our institutions of higher learning has caused a corresponding rise in taxes in general and in particular it has imposed a very considerable financial burden on the families to which the students belong. Some say that the time spent in college is but little better than a four year vacation, a respectable way of postponing the inevitable necessity of choosing and working at remunerative employment. And there are not a few among the graduates each June who would seem to have used their own time and their parents' money only to indulge the frivolous whims of an unambitious, undisciplined, and undeveloped mind.

The four years spent in college, however, may have been utilized in a most profitable manner. Some of the more desirable results may be a thoughtful consideration for the rights of others, a tolerant respect for their neighbors convictions, an ability for and an enjoyment in pleasant coöperation with one's fellows, a capacity for self-enjoyment when alone, the development of real convictions as to standards of life, and a habit of seeking a definite solution for all problems through a fearless, honest balancing of carefully ascertained facts.

The parent curriculum of all college courses is that offered by the College of Letters and Science. Originally, the couse of study was rigidly prescribed, including English, the classics, modern languages, natural philosophy and mathematics. Then there came the elective system which held that students should have a choice of studies. With the development of innumerable highly specialized courses, this range of election grew and grew until a student usually chose over half his studies absolutely as he pleased, although he was supposed to receive the cursory approval of a dean or student advisor.

Thus, it comes to pass that the serious-minded, mature student

receives a thoroughly worth while training; the immature and "butterfly" type of student, under the casual guidance of his classmates, chooses a haphazard conglomeration of courses, which may be good in themselves, but which have little or no correlation; while the shirker chooses a maximum of "snap" courses where he need not "crack a book" during the term. It must be admitted, however, that these last usually "go in for outside activities" with a vengeance and receive a vastly over-rated training in athletics or a form of social life which may be of value in developing the social graces.

There are but few who will not be more than ready to urge that a liberal education is very desirable. The means will inevitably vary, however, with the times, the institutions, and the student. Most American students are mechanically-minded or what is usually the same thing, of a mathematical turn of mind. For those, then, who find mathematics not too difficult, it would be much worth while to consider the advantages offered by an engineering education in the way of achieving the results usually sought from a course in the College of Letters and Science—entirely aside from the possibilities offered by the technical education as to the gaining of a livelihood later.

A large percentage of all engineering curricula is composed of "stiff" courses. To complete any such course of study a student must learn to work hard, regularly and consistently. Such concentration is a form of character training too often entirely omitted from our children's lives.

All types of engineering represent constructive work. If there be destruction, it is only as a necessary preliminary for needed and immediate construction. This attitude tends to give the young student an optimistic, helpful relation toward his human associates and their problems—as a contrast to the aloof, even cynical, attitude one so often finds associated with advanced training.

Machinery will not lie—neither are the physical laws of nature to be fooled or misled by carelessness, wilful prevarication, or a silvery tongue. Mathematical language and explanations must be clear and, above all, correct. These habits of veracity surely and inevitably leave their mark on character. When an analysis or balancing of facts is required, as is usually the case in the solution of a problem either in mechanics or human relations, it is not the question of proving a prejudice, or supporting a client, but rather one of seeking the correct answer without bias or favor. This is a characteristic that cannot be too much stressed under our present condition of civilization. Further, it should be noted that the technical student cannot be satisfied with an open mind and a lib-

eral heart, but he is required to submit a positive answer supported by logical reasoning.

Obviously, such training, if persisted in, develops a citizen with a well considered positive stand on national, local and individual problems.

It is said that engineering curricula are "narrow" in that no work in foreign languages, art, literature, economics, or psychology is included. However, it should be noted that the usual engineering student is required to study English for a period of a year and a half to three years, that practical economics is included in a considerable number of his courses, while applied psychology seems to be mastered by engineers to the extent that they are fast supplanting the lawyer as the chief administrator of "Big Business." A knowledge of the practical facts involved in any special field of human endeavor can be readily acquired from the myriad books now available—whenever the need arises—provided one possesses the proper traits of industry, clearness of thought, and a self-confidence gained through the successful solution of a large number of difficult problems.

While the general course offered by the College of Letters and Science will continue to be best adapted to the needs of a certain proportion of American students, surely, for those capable of completing it, an engineering course offers many real advantages of a purely educational nature for the student seeking a liberal education—entirely aside from its usefulness as a direct preparation for his life's work.

SOME FACTS ABOUT THE SCHOLASTIC ACHIEVEMENTS OF ENGINEERING STUDENTS *

By H. W. MILLER
Professor of Descriptive Geometry, Mechanism and Drawing
AND J. C. PALMER
Associate Professor of Descriptive Geometry and Drawing, University of Michigan

In the autumn of 1923 the Department of Mechanism and Engineering Drawing reached the decision that it ought to be possible to teach all students more efficiently in the subject of descriptive geometry, which is given to freshmen in their second semester, if the high and low students were segregated into classes by themselves. This plan was put into effect the following semester and has been carried on continuously since. From time to time the Department has studied the results of this experiment, but for the most part these studies have dealt only with various phases of the work in descriptive geometry. After a period of seven years, however, it was decided that a sufficient number of these students had graduated, or otherwise terminated their college careers, to warrant a study of their completed records. In the course of this study so many facts of general interest were brought to light that it is felt they should be presented under the above title, rather than to limit the discussion to items concerning a single course; for, while descriptive geometry is still the only course in which the students are regularly segregated, these findings should compel the interest of any department and any college. Indeed, there would be but little point to presenting these facts and observations were it not for the conviction that they are typical of the facts that might be found from an examination of the records of any college of engineering.

Basis of Segregation.—At the beginning of this experiment no one in the Department had had any experience in segregating students, and none had seen any discussion describing the experiences of others beyond certain explanations of various methods of segregation and the advantages that might result. It was necessary, therefore, to make some arbitrary decision as to the basis of segre-

* A modified version of a lecture delivered before the Engineering Drawing and Descriptive Geometry Session of the Summer School for Engineering Teachers, Carnegie Institute of Technology, June 14, 1930.

gation: whether segregation should be based on special tests, on previous scholastic records, or on the basis of some index of general intelligence and capacity. It was decided finally to classify students on the basis of their total achievements during their first semester in college, rather than on the basis of isolated achievements or on the results of tests. In general the first semester programs include courses in English, chemistry, college algebra, engineering drawing and possibly a foreign language, to the total of about sixteen of the one hundred and forty units required for graduation. The grades received at the end of the semester are in terms of A, B, C, D and E, which have the mathematical values of 4, 3, 2, 1, 0. It was decided to use the mathematical average on all work of the semester as the index for classification. The maximum that any student can have is 4, provided he receives the grades of A on all subjects, and the minimum average is zero, provided all grades are E.

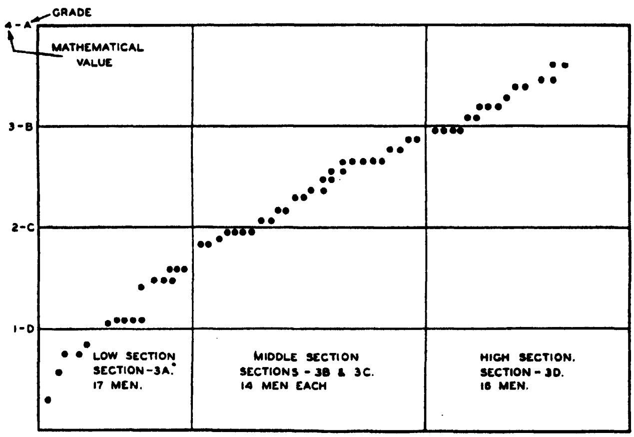

FIG. 1. Division of 61 students of Descriptive Geometry (Drawing-2) into sections, on the basis of scholastic records.

Sectioning.—The average grade of approximately 3 was set as the division between high and average students and approximately 1.5 as the division between average and low students. The experiments have been conducted at all times under average working conditions. Students are enrolled in six different groups according to the hours of the week when they report for work. No attempt has ever been made to influence the group registration of any student. When the list of registrations is received by the Department, it is usually found that there are six groups of from fifty to sixty stu-

dents each, which must be divided, if possible, into sections of not more than fifteen and not less than twelve. For reasons which need not be discussed here, fifteen has been set as an ideal number for a section in descriptive geometry.

Figure 1 shows the arrangement of one of the groups of approximately sixty students as they appeared in February, 1924. When they had been arranged as shown, a section of sixteen was selected from the higher end and one of seventeen from the lower end. It is clear from examination of the diagram that the division point is but arbitrary. The division between the low and average is sharper than that between the average and the high. Two more students might easily have been included in the high section. It is possible even that they should have been included.

The students remaining when the high and low groups had been drawn off were divided into two sections of fourteen each. The lowest of the average men differed very materially in their rating from the highest, and perhaps ideal segregation should take this into account. Actual working conditions do not make this easily possible, however. Since the same practice has prevailed in the segregating of students in the subject of descriptive geometry during the intervening seven years, there is now available the data of seven consecutive years for comparative study.

Qualities of Students.—Immediately after the students had been divided into three classifications, studies were undertaken to learn as much as possible about their capacities and qualities in terms of previous achievements. Whenever the subject of segregation is discussed, one is almost certain to hear mentioned the idea that poor students are inspired to better achievements if permitted to work with the superior ones. There are those who declare that it is not detrimental to the progress of the high students to have the low ones with them in class. A study of the situation as it prevailed when students were taught in heterogeneous groups revealed that there were usually three or four high and three or four low students and twelve to fourteen average ones in a section. It has not been possible to determine, however, to what extent the ordinary administration of heterogeneous groups can or does cater to the capacities and caliber of the superior students while attempting to give every possible opportunity to the inferior ones.

Figure 2 illustrates the achievements of *all* students in *all* subjects during both semesters of the second year of segregation, 1924–25. The facts recorded here are so significant that they are worthy of painstaking study. It is so seldom that one conducts a searching examination of the achievements of students that a revelation of the facts is startling. A discussion of all that is recorded

on these diagrams would be so tedious that only a few will be dealt with. One fact which they disclose is that we are too prone to generalize about the qualities and achievements of students. It is only when they are classified and divided into groups *according* to their achievements that one can learn the facts.

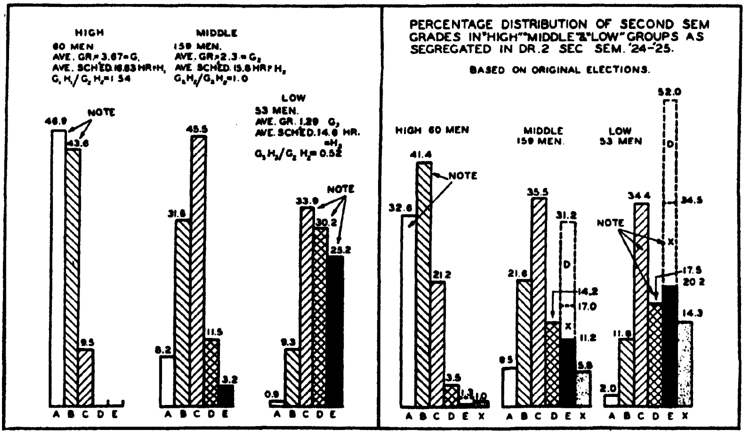

FIG. 2*a*. FIG. 2*b*.

Figure 2 illustrates the wide differences that exist between our high and low pupils in terms of their accomplishments. The high and the low students in the beginning class of 1924–25 are shown here in terms of their achievements in all subjects. It is still the normal practice in college to attempt to teach students of such widely different qualities in the same sections, and presumably to the best interests of all. In the second semester the high students carried an average of 16.7 units with an average grade of 3.04. The low students carried an average of 13.7 units with an average of 1.78. The very pertinent questions arise as to how men of the apparent caliber of the high student can possibly work with the others without permanent injury to themselves and whether the second group can possibly be benefitted by what might be termed inspiration from contact with their superior fellows. Do not the low men suffer from the association, develop inferiority complexes, become quickly discouraged and serve as a handicap to both the class and the instructor?

Another significant fact which appears on Figure 2*b* is an X or withdrawal column. *This withdrawal column is most striking with the low students.* There is a date in the semester after which students are not permitted to withdraw from a subject except with a

grade of E. Few freshmen avail themselves of this privilege during the first semester. They have not been used to the privilege of withdrawing from work when it becomes too difficult. They learn from their older friends that if they are to save themselves from being dropped at the end of the second semester, they had better get out of those subjects in which they seem to be failing. The X column should really be added to the E column and on this basis it is seen that such students have an E column of thirty-four per cent in the second semester as compared with twenty-five per cent in the first. The natural question is why do we permit withdrawals at any time except with the grade of E if that be the student's probable fate? In addition, work of grade D can hardly be termed satisfactory and might better be classed with the grades of E. The low students then have a failure column of fifty-two per cent. The combined D, E, X column does not detract from the record of the high students.

The Completed Study.—Although the Department has continued to investigate the progress of the students who entered college in the three years, 1923, '24 and '25, it was not possible to complete the study until the past summer. Some students are in and out of college for six years or more. Some require a total of five years to complete the four-year curriculum. It was not possible, therefore, to complete the investigation of the entire college performance of these students before the end of this past school year.

The data charted in Figures 3 to 9, inclusive, represent the cases of all of the high and low students during the three years, 1923–'24, '24–'25, '25–'26, together with the middle group for 1923–'24 only.

Some of the questions which it was desired to answer were: (1) What is the degree of correlation between the first semester achievement index employed as the basis for classification and segregation and the achievements of the full four years; that is, what is the relation between the percentage of units of work completed with the grade of A in the first semester and the total percentage of units of grade A completed in the entire curriculum. (2) What happens to our superior students? (3) How many years are required by the average and poor students to finish the four-year requirements? (4) What is the trend of the quality of the work of all students as they proceed through college? (5) What is the effect, if any, on high students of the practice of teaching them in classes with average and low students? (Descriptive geometry is still the only subject in which all students are regularly segregated.)

Figure 3 illustrates the relation that was discovered between the distribution of grades received by the three classes of students on

their first semester work and on the total accomplishments in college. The curves which represent the distribution of letter grades for the fifteen to eighteen units for the first semester are so nearly identical with the curves which represent a similar distribution for the entire four or five years that it seems reasonable to conclude

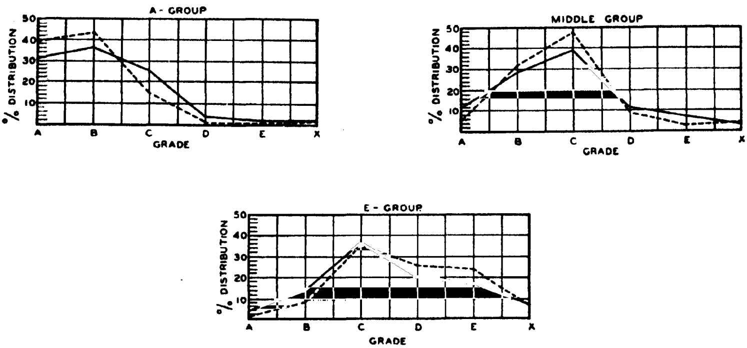

FIG. 3. Comparison of first semester grades and total grades earned by group. (Legend: First Semester Grades - - - - -, Total Grades ———.)

that *the first semester index of the students' prospects in college is as nearly perfect as one could wish.* To all intents and purposes the curves are the same. If the curves warrant this conclusion, it is evident then that numerous fond ideas with reference to a student's finding himself in college or doing poor work in certain subjects because they are not to his liking, have little support in fact. Of the one hundred and fifty-nine students classified as "High," one hundred and seventeen graduated. Of the forty-two who withdrew before graduation, only two left the college with a total grade average less than 2.0. Of the one hundred and forty-nine students classified as "Low," nineteen graduated. Of the one hundred and thirty who withdrew before graduation, only two left with a total average as high as 2.0. A certain percentage of high students find that they do not like engineering. They do not learn this fact, however, through poor accomplishments. They seem to do good work out of mere self-respect. They simply come to the conclusion that engineering is not what they thought it is and they do not like what they find it to be. On the other hand, experience with low students fails to support the idea that they might have been more successful had they started in some other part of the university. Their poor achievements seem to be the result of poor preparation, lack of interest, lack of industry and lack of ability. The agreement between the first semester and the four years' achieve-

ment curves is so perfect that the low student might profitably accept the verdict as a prediction of his probable prospects.

Endurance Prospects.—Figures 4, 5 and 6 show some interesting facts with reference to the possibilities of all students in terms of the number of years they might be able to continue in college and the differences which exist between students who finish in four years and others who finish in five.

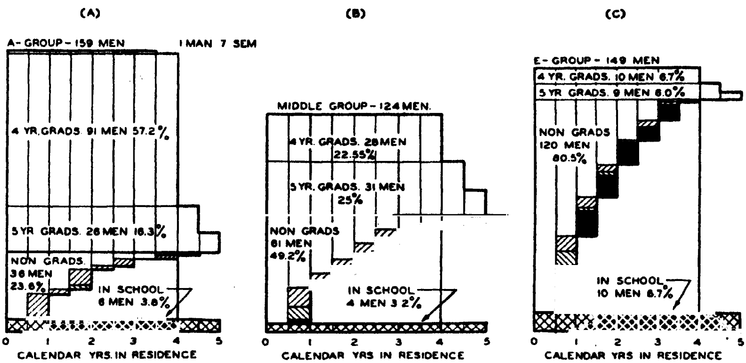

FIG. 4. Life charts of high, middle and low groups.
(Legend: Requested to withdraw for scholarship ▬▬▬ Withdrew ///// Withdrew while on probation \\\\\.)

Seventy-three per cent of the high men graduated. A total of twenty-three per cent left college of their own choice, either because they did not like engineering or for economic reasons. Seventy-two per cent of those who graduated did so without any seeming difficulty in the four years. The curve of achievements of the four-year men on Figure 5 is noticeably higher throughout than the curve of the twenty-seven per cent who required five years. This is worthy of attention. It is commonly believed that there is not much difference between the caliber of the men who graduate in four years and those who graduate in five. It is generally thought that economic difficulties are responsible for the five-year students, particularly if they be reasonably good students. Whatever we may like to think the reasons are for the additional year, we find one pertinent fact from a study of achievements, that the five-year men are inferior to the four-year men from the very beginning.

Fortunately for this investigation, the College was particularly lenient in giving the low students the benefit of the doubt as long as there seemed to be any possibility at all of their completing the curriculum. This group started with one hundred and forty-nine men and nineteen of them succeeded in graduating. Figure 4C indicates that very few arbitrary actions were taken to drop such

students until the trend of their achievement had descended to the point where it was clearly impossible for them to graduate. A total of one hundred and twenty, or eighty per cent, of the one

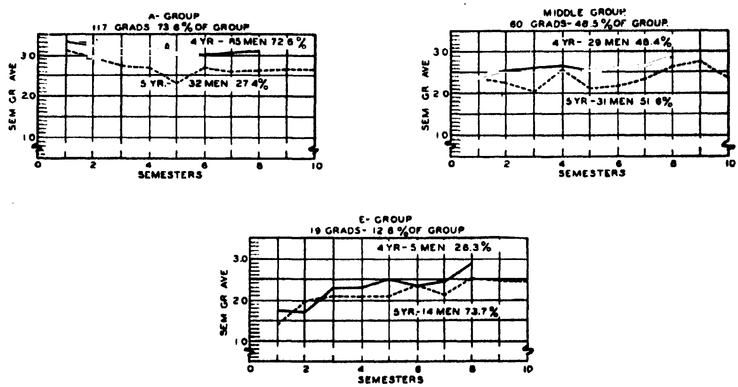

FIG. 5. Comparison of grades of four-year and five-year graduates. Semester grade averages.

hundred and forty-nine men, were "continued on probation" and usually with reduced schedules of hours until the last of them was disposed of at the end of the first semester of the fourth year. Of

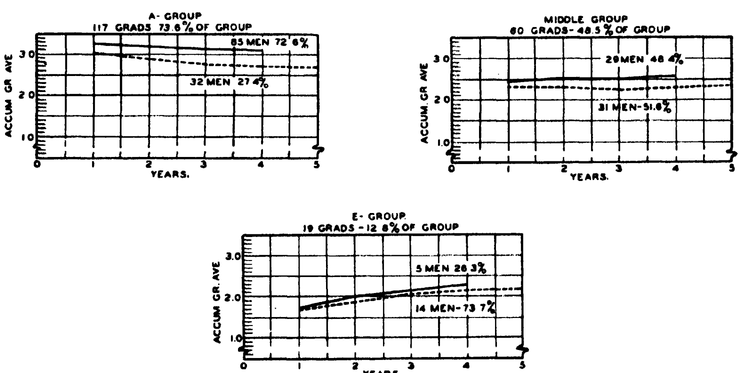

FIG. 6. Comparison of grades of four-year and five-year graduates, Accumulated grade averages.

these one hundred and twenty students, seventy-nine were finally requested to withdraw on account of poor scholarship and another fourteen voluntarily withdrew while on probation. Although these students were in school for periods of from two to seven semesters,

it is very doubtful if they actually were benefitted by their stay. Collectively these ninety-three students spent three hundred and thirty-seven semesters in college. The College officially branded as unsatisfactory (Probation and Home List) two hundred and sixty-nine semesters, or eighty per cent, of this work. Can we believe that the doubtful benefits derived by such work offsets the serious delay in getting these students started upon whatever other careers they eventually pursued? The College estimates the average yearly expense of a student in engineering at something between $800 and $900. Upon a basis of the lower figure, we find that these ninety-three students wasted, or at best spent in a very futile effort, not only one hundred and sixty-eight years of young manhood but something in excess of $134,000, to which must be added an equally formidable item of expense borne by the University. Since Figure 3 shows such excellent agreement between first semester performance and total accomplishments, a very pertinent question is, *why do we permit such students to continue so long in college after they have demonstrated their possibilities so clearly?* Is it fair to these students themselves, to the average and high students who must be taught in the same classes with them or to the instructor who must labor with them, or to those who pay the bill for maintaining the university? Is it not probable that these men develop such a sense of inferiority before they leave college that the idea is fixed in them for life? Could any greater injustice have been done them had they been dropped at the end of the first semester or at the latest at the end of the second semester on the basis of their records? Finally, what chances have the nineteen men who finally graduated for success in the profession of engineering, since but a brief investigation reveals that the engineering work of the country is being done by less than one half our graduates. Is it not true that the competition for success in engineering is actually between individuals of the superior group and that the average and lower men must certainly do something else?

Figure 7 serves to illustrate the quantitative as well as qualitative differences between the accomplishments of the graduates who were classified in their second semester as high, average or low students. Those in the high group received grades of A on a total of thirty-three per cent of their college work. They required one hundred and forty units for graduation and they had more than the required total stamped with grades of A, B and C. The average students had but thirteen per cent of A as compared to thirty-three per cent by the superior students and had only one hundred and thirty units of quality A, B and C. They had to use ten of the quality of D, a sort of compromise grade. The low students com-

pleted but fourteen units with the grade of A. They found it necessary to use not only their A, B and C work, but practically every unit of work of the grade of D that they possessed to graduate. The interesting fact is evident, too, that they average a total of

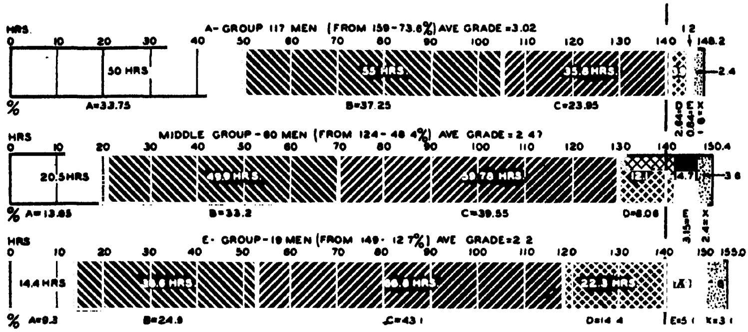

FIG. 7. Comparison of quantity and quality of work done for graduation.

one hundred and fifty-five units of work taken in order that they might pass one hundred and forty units, even including the fourteen per cent of grades of D.

The Slump of the Superior Students.—Figures 8 and 9 are termed Performance Charts. They are perhaps the most interesting and certainly the most important of all. It was shown on Figure 3 that the correlation between the first semester and the four-year achievements of all qualities of students is nearly perfect. Students do demonstrate their capacities and possibilities in their first semester in college. Superior students demonstrate that they are superior and inferior students demonstrate that they are inferior. The question arises, then, at the end of a superior student's first semester as to whether he should not continue throughout college to be just as superior as he has just shown himself to be. And if not, why not? Is it not true that our finest athletes attain their greatest success by virtue of training suited to their particular abilities and to competition? Figures 8 and 9 illustrate the facts for superior average and low students. The G. H. (Grade $\times$ Hours) or quality-quantity index of achievement is employed in determining the curves. This G. H. rating ought surely to be a capacity index, but one is almost forced to believe that with the high students it is but a performance index.

Figure 8*a* shows that from the end of the very first semester the achievement curve of high students slopes *downward,* while the achievement curves of the average and low men rise. Why? Figure 8*b* is for graduating students only and is worked out on the

basis of years instead of semesters, thereby approximately doubling the ordinates. The trends are the same as on Figure 8*a*. Another curve is given on this diagram which may furnish the clue to the reason for the downward slope of the curve of the high men. It is the curve of achievements of all graduating students, high, average and low. As one would expect, it is below the curve of A, or high students, and above the curves for the middle or average and E, or low students. Is it not probable also that this fourth

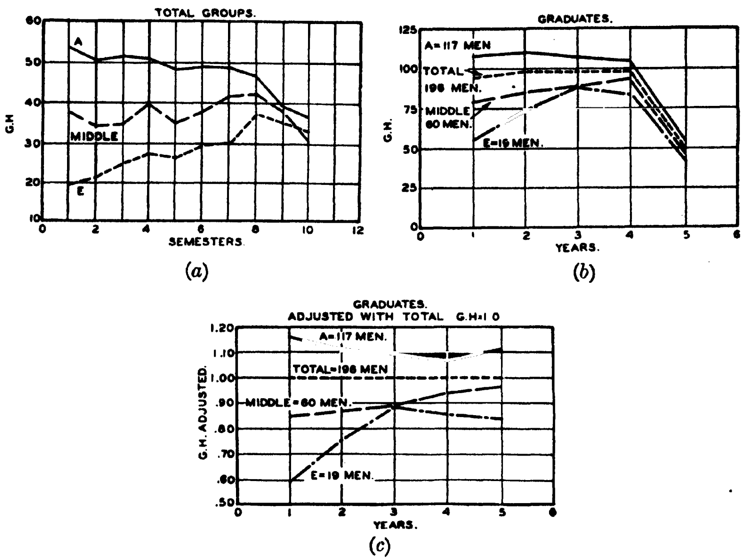

FIG. 8. Comparison of G.H. factors for high, middle and low groups.

curve indicates not only the average achievements but something of the mental plane of instruction throughout college? Perhaps it is even optimistic in that respect. In most athletic competitions we conduct elimination tryouts or tests. As a consequence, the men who compete in the final 100 yard race are all approximately ten second men. High students are just as human as the low although apparently they are not supposed to be. They need to be paced, praised, corrected and trained. They need experienced, talented, sincere, hard working teachers. No others will succeed in developing the best that is in our finest students.

Figures 8*c* and 9 comprise two sets of comparison curves. First, in 8*c*, the average achievement curve of 8*b* is regarded as unity throughout and the other three curves are adjusted accordingly. This may not be the proper way to appraise the achieve-

ments of the high men, however. On Figure 9 the ideal achievement, that is, one-fourth of the total curriculum (thirty-five hours) carried each year, and all subjects completed with a grade of A (4), is set up as the perfect performance (100%). The values on the curves in this diagram for the fifth year are not comparable with those for the first four years. In each group the men who graduate in the fifth year are able to do so with less than an extra full year of work at normal schedule. This reduction in the num-

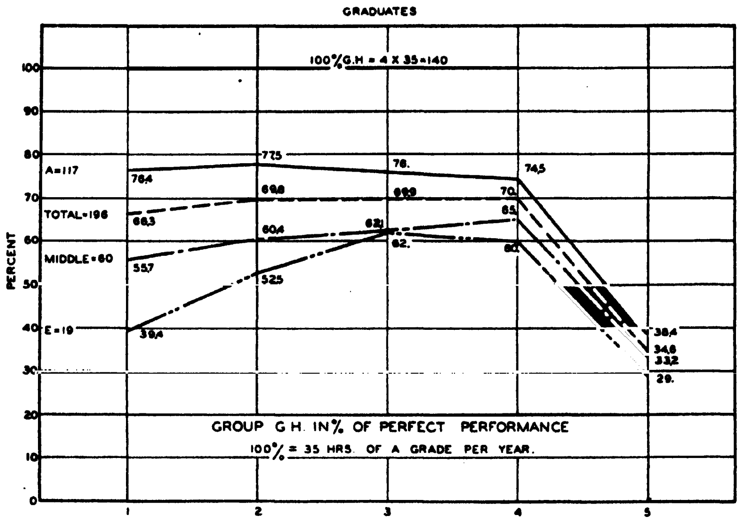

FIG. 9. Group G.H. factors in per cent of perfect performance.

ber of hours carried in the fifth year accounts for the lower values of G.H. Figure 9 shows that the average capacity, or performance, of all of the students remains constant at about seventy per cent. throughout the last three years. The significant fact is that the low and middle students show a marked improvement while the high students show a steady decline during this period.

In Conclusion.—Aside from the seemingly evident fact that our high and low students can be quite accurately selected during their first year in college, no attempt is made to draw further conclusions. The following pertinent questions may well be raised, however. Would the conditions noted in Diagram 9 be the same if the high and low students were taught in segregated classes throughout their course? Is the improvement shown by the low students due in some part to inspiration received from the high students? Is the decline of the high students accounted for in some part by a

growing sense of superiority and self-satisfaction due to constant self-comparison with fellow students whose average capacity is below their own? Would the high students be inspired to maintain and improve their demonstrated abilities if taught in segregated groups where their work would be compared with that of their mental equals? Is some of the time and effort required of the instructor, and of the class as a whole, to pull nineteen poor students up to a graduation standard being made at the expense of one hundred and seventeen superior students? Are we justified in retaining in our classes, for periods up to seven and eight semesters, one hundred and thirty low grade students who can never graduate, if their presence detracts in the least from the performance of the superior students? Are all conditions satisfactory when our best students maintain a seventy-five per cent perfect performance? In conclusion and in summation: are we so much concerned in salvaging inferior and mediocre material as in developing our finest material?

CAN THE TEACHER JUSTIFY HIS JOB?*

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To most classroom teachers it would doubtless seem unthinkable, if so preposterous an idea should ever occur to them, that education might go on quite as effectively as at present even if classroom teachers were to be universally abolished. Teachers in general are apparently accustomed to take it for granted that they, as teachers, are indispensable to any orderly and effective scheme of formal education. They would doubtless base their claim to indispensableness upon the two-fold responsibility which is theirs: the responsibility, on the one hand, for stimulating and inspiring the students entrusted to them, and the further responsibility, on the other hand, for adapting the various phases of the teaching process to their students' special abilities and needs. In the duties which teachers supposedly perform in connection with each of these vital responsibilities, no agency except the classroom teacher (so most teachers would seem to assume) can ever render thoroughly effective service.

So widespread is this assumption that any serious questioning of the classroom teacher's importance is likely to be rare. Yet such questioning does occasionally take place. It has most recently taken place as a result of certain investigations which have been concerned with the direct results of the classroom teacher's work. In so far as these investigations have brought forth even tentative conclusions, they have almost uniformly given room for serious doubt as to the average teacher's real contribution to his students' learning.

The investigations which have furnished most immediate occasion for this doubt have had to do with the effectiveness of so-called individual-instruction materials. Numerous educational experimenters have developed plans for teaching, of which the Dalton and Winnetka Plans are perhaps at present the most widely known, which largely or entirely displace the classroom teacher in many phases of the teaching process. Instead of teacher-conducted "recitations", these plans provide for individual work on the part of the students. The work is based on printed or mimeographed assignment or "job"-sheets, which contain references to

* Summary of a discussion presented at the Civil Engineering Session of the Summer School for Engineering Teachers, Yale University, July 3, 1930.

appropriate reading and practice material, directions for laboratory exercises or for the solution of special problems, and examinations for the rating of the students' achievement. The most completely developed materials of this kind make it possible for the students to proceed with only occasional recourse to the teacher, who finds himself relegated to the background to take charge of the somewhat minor duties of seeing that students make proper use of their materials, supervising the administration and marking of examinations, and keeping records of each student's accomplishment.

These new methods have been introduced with apparently promising results not merely in elementary schools and high schools but in colleges as well. They have been tried with a great variety both of different subjects and of different types of students. Though their effectiveness has not always been carefully tested, particularly when they have been introduced on the college level, the tests which have been made seem in general to permit of a uniform interpretation: that students learn at least as much through this scheme of individual study without a teacher, as through the usual plan of classroom procedure directly guided by a teacher.

In the light of the results from such tests as these, the classroom teacher would seem to find himself hard pressed to defend his supposed indispensableness. Does the teacher actually stimulate and inspire his students? Perhaps; but if stimulation and inspiration are to be measured by their effect on students' learning, then as between carefully worked out printed materials and the average teacher, printed materials can evidently accomplish as much. Does the teacher adapt his instruction to his students' individual abilities and needs? Again perhaps; but if what the students learn may serve here also as a measure, printed materials once more can accomplish as much. The teacher cannot fairly claim to be indispensable unless he can demonstrate his ability either to perform some duty which no other agency can perform, or at least to perform some duty better than it can otherwise be performed. And so far as his duties as stimulator and inspirer are concerned, or his further duties as manager of learning procedure, such investigations as these suggest that the average teacher can lay slight claim to the dignity of being considered indispensable.

Certain other investigations raise no less serious questions as to the teacher's importance, though from a different point of view. If the classroom teacher does succeed in stimulating and inspiring his students and in adapting his instruction to their individual needs it is reasonable to suppose that his teaching will be more effective when he has to deal with small groups of students than when he is confronted with large. Extensive studies have been made of the effectiveness of teaching in large classes as compared with small.

One of the most recent of these studies, and one of the most comprehensive and carefully planned, was carried out in the University of Minnesota.* Its tentative conclusions agree with those to which nearly all previous objective studies of this sort have led: that largely irrespective of what is being taught or who is being taught or who is doing the teaching, students in large classes learn at least as much, on the whole, as do students in small classes. There is here no evidence, of course, that the classroom teacher can profitably be dispossessed of his job. But there is also no evidence that the classroom teacher fulfills his responsibilities on any other than a chiefly routine and automatic basis; so that those prophets of a new day who foresee some mechanical device—a talking motion picture, for example—displacing the teacher of the present order, can find in these investigations, as well as in those previously described, much with which to buttress their prophecies.

There will be many who will object to the conclusions to which both these types of investigations seem to lead. They will maintain, perhaps, that the teacher's most important contribution is unmeasurable—an intangible something which does not lend itself to analysis by objective means, but which nevertheless influences the student directly and valuably. They will emphasize the limited numbers of teachers and schools taking part in both types of investigations, and will insist that whatever may be true of other teachers and other schools, their own scheme of teaching is superior to any which might be substituted for it. They will object that the teacher does contribute something to learning, however poor his teaching may be, else his students would never learn. In all these objections they will seek for some ground on which to defend not only themselves but all of us who are classroom teachers, from the charge that our work might go on quite as well without us.

To those who object that the teacher's contribution is intangible there can be no final answer. Intangibles, by definition, cannot now be measured and can never be measured. They cannot, indeed, even be reasonably disputed; so that the views of a person who holds that the classroom teacher makes an intangible contribution superior to the contribution offered by printed study-materials or by talking motion pictures can no more be disproved than can the views of one who holds the very opposite. Proof, and evidences leading to proof, can only be concerned with tangibles; and in so far as tangible evidence can at present be drawn upon as a gauge of the teacher's success, it does not seem to support the view that the teacher is indispensable.

Those who believe that they themselves, and their schools, repre-

* Hudelson, Earl: *Class Size at the College Level*, University of Minnesota Press, 1928.

sent exceptions to any present conclusions can likewise be given no final answer. It can only be pointed out that the schools and the teachers thus far subjected to these investigations represent a considerable number of educational institutions of various types, and that these institutions were apparently doing teaching of at least average effectiveness under the usual scheme of classroom procedure. In the light of present evidence the burden of proof is on the teacher who believes himself an exception. Does he inspire and stimulate his students more effectively than most other teachers, the country over? Does he adapt his teaching more skillfully to his students' needs? He must show that he is truly superior to teachers in general in these respects, before he can claim greater immunity from suspicion than the results of the investigations thus far conducted would seem to warrant.

The most widespread objections are likely to be voiced, however, neither by those who believe in the intangibility of the teacher's contribution nor by those who consider themselves exceptions to the general rule, but by those who maintain that the teacher's contribution is too obvious to need proof. The teacher does teach and the students do learn: is not the latter fact sufficient proof of the former? It is, indeed; but as an argument for the indispensableness of the teacher it falls, unhappily, very largely beside the point. The investigations do not show that the teacher does not teach: they suggest simply that other agencies can teach as well as he. And suggesting this, they give room for a very plausible doubt as to whether the classroom teacher is actually the significant factor in teaching that he has long been assumed to be.

Hence there is little exaggeration in saying that the classroom teacher, even though he may not be aware of his predicament, is face to face with a serious problem: can he actually justify his job? If the results of these investigations mean what they seem to mean, the teacher cannot fairly assume that his position in the classroom is permanently assured. Talking motion pictures may some day be less expensive than salaried human teachers. Individual-instruction materials are already available for numerous subjects and various types of students, and are less costly than the teachers whom they might displace. Unless the teacher can establish for himself a place in teaching which cannot be filled by these mechanical systems or others of a similar sort, he is likely slowly but surely to find himself one of a vanishing race. Is there a place left for him, or can he be kept from the extinction that may otherwise be his only by public inertia, or by an emotional appeal to his vested rights?

Fortunately for those who are immediately concerned, there is reason to believe that the teacher's present lack of success in prov-

ing himself indispensable can be more or less adequately explained. Any valid explanation of the teacher's relative ineffectiveness is worth considering with some care, since it is likely to indicate a type of procedure which teachers in general will do well to avoid if they are to justify their work, and since it may thus provide a starting-point for determining what types of procedure may in the end prove themselves of undeniable worth. In the present instance, the explanation which suggests itself would seem to have significant bearing on teaching procedure at almost every educational level. It can be most readily illustrated, however, in terms of teaching in the secondary school. Hence there may be profit in considering this explanation with direct reference, for purposes of illustration, to methods of teaching in various secondary-school fields.

The methods of teaching ordinarily followed by secondary-school teachers are surprisingly uniform from school to school. They are so uniform, indeed, that one who spends much of his time in observing school work can predict with extraordinary accuracy the kinds of activities in which the students in any given class will be engaged during the class period. If one visits, for example, a few classes in plane geometry in no matter what secondary schools, one will find in seven or eight classes out of ten almost exactly the same procedure. The geometry teacher will use the first part of the class period by sending to the blackboard as many students as the size of the board will allow, to write out the demonstrations of theorems or originals assigned for that day. Meanwhile he will engage the attention of the rest of the class by calling on them for oral recitations—the solution of review problems, or drill, or perhaps one of the assigned demonstrations being placed on the board. When the students at the board have finished their work the class recitation will abruptly cease, and those who have written out their demonstrations will return singly to the board to present and defend their proofs. The proofs completed, the class-period will be almost over. The teacher will assign further demonstrations, or possibly review, for the following day, with such explanations and comments as time may permit or his conscience may urge. Then the bell will ring and the class will disperse, later to "get" their assignment according to their individual and unaided abilities and inclinations.—Or let one visit a random group of classes in high-school French. A few students copying sentences from the assigned English-into-French on the blackboard, one sentence to each student, while the rest of the class, at their seats, "do" an oral assignment or a drill on vocabulary; an explanation and defense, addressed largely to the teacher, of the sentences written on the board; recitation of the French-into-English exercise for the day; a laborious and joyless translation

from "Le Voyage de M. Perrichon" or "Le Bourgeois Gentilhomme," taken up in the middle, carried through student by student and bit by bit, and broken off a page or two from where it was begun; more exercises, vocabulary, translation to "get" for tomorrow announced as the period closes—this is what the visitor will find in class after class and school after school.—Visit English classes, or science classes, or classes in the social studies or in commerce: the result will be the same. The exact procedure which is followed will differ in detail from one subject to another as the subject matter itself differs, but within any single subject the methods of teaching will be notably regular and uniform.

The methods of teaching are surprisingly simple in outline, moreover, as becomes apparent when one attempts to analyze them. Whether in mathematics or foreign language or history or science or English, the teacher's procedure ordinarily consist of three major parts: setting tasks which the students are expected to perform outside of regular class meetings; providing, either through textbooks or through oral explanations, the materials to be used in performing these tasks; and examining and "marking" the results of the students' attempts to perform them. With so simple an outline of procedure as this, it is hardly surprising that methods in any single subject are almost identical everywhere.

Yet the significant thing about customary high-school procedure is neither its uniformity nor its simplicity. Much more important is the kind of learning which these characteristics of the teaching process demand of the student. He learns, for the most part, not in class, but outside of it, since the classroom time is given up almost entirely to the teacher's examination of the results of his learning. He learns individually, moreover, "getting" by himself outside of class (if he is honest according to the school's arbitrary definition of honesty) the assignment which the teacher has set for him. And he learns largely from books, supplementing the information or directions which the assigned texts contain with whatever recollection he may have of the further information or directions given him by the teacher. It is with learning of this sort on the part of the student that schemes of teaching which would displace the classroom teacher have to compete.

Relying on such teaching methods as these, can the secondary-school teacher fairly expect to show himself indispensable? He assigns, he explains, he tests. Individual-study materials likewise assign and explain and test. Learning directed by the teacher is almost the exact counterpart of learning directed by assignment-sheets; and though students may be expected to learn from the teacher as well as from assignment-sheets, the teacher can hardly be said to teach except as assignment-sheets teach.

Thus there would seem to be a reasonable basis afforded merely by an examination of the teaching procedure which most high-school teachers are content to use, for explaining the relative ineffectiveness of the high-school teacher's work. So far as secondary-school teaching is concerned, the classroom teacher fails to accomplish more than can be accomplished by purely mechanical teaching devices for the simple reason, apparently, that he uses methods of teaching which are in themselves almost entirely mechanical. He meets automatic teaching schemes on no other ground than the one which such schemes can themselves easily occupy—that of routine instruction of individual students, largely through formal textbook materials; and meeting these schemes merely on their own ground, it is hardly to be wondered at that he does not shine brightly by contrast.

The present discussion is immediately concerned, however, not with teaching procedures in secondary schools, but with teaching on the college level, in schools of engineering particularly. The uniformity and undesirable simplicity which seem to characterize most high-school teaching may not be equally characteristic of engineering education. It will be pertinent in any case, before drawing broadly general conclusions from secondary education alone, to consider what the facts may be with respect to teaching procedures in schools of engineering.

To describe college classes in general—and what is true of most college classes is doubtless true of engineering classes—is more difficult than to describe high-school classes in general. The difficulty does not rest, presumably, in the greater complexity and variety of procedure in individual college classes. It springs rather from the obstacles which the principle of academic freedom sets in the way of observation of college teaching. Few persons have had enough glimpses of college work in general to permit them to draw far-reaching conclusions about it. Hence it seems impossible, in the present instance, to offer the kind of description of college classes which is possible in connection with classes in secondary schools. But in place of such a description certain questions may perhaps be raised—questions which bear directly on the matters under discussion, and which may suggest, even though they cannot support, significant conclusions with respect to college teaching.

Does not the usual college teacher—and this includes the teacher of engineering—spend a major part of each class period merely in delivering prepared information to his students? Or, if he welcomes discussion in his classes, does not the "discussion" consist largely in the teacher's supplying the answers to questions which his students raise? When the teacher himself raises questions in his classes, are the questions not in effect largely rhetorical ques-

tions, which he expects—and his students expect it of him—to answer himself in detail, after a brief time has been given to feints at them by the students? If the teacher's method involves requiring daily recitations from his students, do not these recitations consist merely in his examination, point by point, of the results of students' outside study? If the teacher conducts laboratory periods, do not these periods afford simply a well-systematized opportunity for students to do what they have been given directions for doing? Does the college teacher, in other words, do more than set tasks for his students, provide them with information, and examine them as to the results of their outside study? Does he, any more than the high-school teacher, ordinarily offer his students a type of teaching which could not quite as effectively be reduced to print or supplied through talking motion pictures?

Such questions as these are obviously unanswerable for college teachers in general, because of the impossibility of supporting any general answers by reference to demonstrable facts. One can at best offer only a surmise as to what the answers may be. On the strength of such a surmise it will be not unreasonable to hold that there are numerous college teachers whose teaching—like the teaching of many secondary-school teachers—will stand well the scrutiny which these questions provide. Nor will it, perhaps be unreasonable to believe that there are many other college teachers who can show in their teaching few procedures which offer an advantage over purely mechanical teaching devices. So far as the results of experimental studies throw light on the matter, college teaching and teaching in secondary schools seem to be about equally subject to replacement by mechanical schemes. For want of adequate evidence to the contrary, one is almost forced to the conclusion that the apparent ineffectiveness of college teaching procedure is to be explained on essentially the same basis as the ineffectiveness of most high-school work. The college teacher, like the secondary-school teacher, is faced by the need to justify his job; and he can find adequate means for justifying it only by recognizing the apparent probability that his teaching, like most secondary-school teaching, tends at present to emphasize merely routine instruction of individual students, largely through formal textbook materials.

This, then, would seem to be the status of the classroom teacher in college and secondary school alike: the teacher teaches and his students learn, but the teacher teaches after such a fashion that purely mechanical devices can successfully reproduce both the methods and the results of his teaching. The teacher can prove himself actually indispensable in the teaching process only if he can bring about some change in this status. There is obviously one direction, and one direction only, in which he can make a change

which will be adequately effective. That is in the direction of improvement in his own methods of teaching. Somehow or other he must find for himself a scheme of teaching which contributes unmistakable values to the learning of his students, and which at the same time cannot be reproduced, either in method or in effect, by any purely mechanical "system."

That such a scheme of teaching may be found is by no means inconceivable. No such scheme has as yet, to be sure, had its value objectively proved, since none has been tried long enough, or comprehensively enough, or by enough teachers, to give a measure of its strength. At least one scheme of this sort, however, seems of particular promise. It is one which mechanical devices can hardly imitate because it involves more than a routine setting of tests and imparting of information. It is one which may be looked to for results of undoubted value, since it tends not toward mere rote acquisition of formal knowledge and skills, but toward development of the ability to use essential knowledge and skills under conditions in which their use is important. It is a scheme which demands a broader background, greater adaptability, and more exertion on the part of the teacher than does customary classroom procedure. But it gives the classroom teacher full opportunity to prove himself indispensable; so that it is well worth the attention of any teacher who is seriously concerned to justify his job.

The teacher who would adopt this scheme needs to recognize certain facts which in the long run will have much to do with determining the relative success of his teaching.

In the first place, he needs to recognize the fact that class-teaching involves the teaching of *groups* of students. This would seem to be almost self-evident. That it is by no means self-evident in practice is clearly attested by the teaching procedure which most teachers use. The methods of teaching employed in the average high school, and the methods presumably followed by most college teachers, recognize classes of students as mere collections of individual students many times repeated. The teacher addresses himself to a class in almost exactly the way—except, perhaps that his language is more formal—in which he would address himself to an individual student; he calls upon the class during the class period for tasks which are to be performed separately, even though simultaneously, by each individual in the group; he tests his students' achievement almost entirely in terms of what each one, quite independent of the others, has been able to accomplish. Yet he has before him a group of persons at least potentially interested in the same general problems, able to contribute in varying ways and varying degrees to the mastery of those problems, and possessed of

a "group psychology," so-called, which is likely to be of no small significance in their learning.

In the second place, the teacher needs to recognize the fact that the process of group learning, when it is economically and effectively conducted, involves a procedure more or less distinctively its own. People learn in one fashion when each must learn by himself, but in a somewhat different fashion when they can coöperate in learning. The methods of learning which coöperation makes possible ought properly to form the basis for class teaching, if class teaching is to be regarded as synonymous with group teaching.

And in the third place, the teacher needs to recognize the fact that his own part in teaching is chiefly to be found in the contribution which he can make to group learning. Students can profit, through their association with each other in groups, in ways which are not open to them merely through individual learning. Group learning is, therefore, distinctly worth providing for. But whereas individual learning can be more or less successfully guided through various mechanical "systems," the effective conduct of group learning seems likely to be beyond the scope of any merely mechanical device. Hence it is in the conduct of group learning that the classroom teacher must probably seek his own eventual justification.

Obviously the most important task which confronts the teacher, therefore, is to determine what group learning must involve if it is to be economically and effectively conducted. The teacher's ability to provide the conditions under which such learning may take place, and his skill in guiding it to worthwhile ends when it does take place, are likely to represent the principal measures of his success as a teacher.

Group learning is common enough, fortunately, so that examples of it are not hard to find. One has only to observe a number of people who have come together to achieve a common purpose—provided, of course, that they are not dominated by some dictatorial person who establishes himself as their teacher—and one may find in what they do and how they do it a clue to the process which such learning involves. A single instance of this sort will perhaps serve to indicate what takes place when people learn as a group.

This instance is drawn from the history of a certain New England town, some of whose citizens awoke one day to the disturbing realization that the town had no sewer system. These citizens followed a procedure usual in such cases: they wrote letters to the editor of the local newspaper. From the publication of the letters there resulted enough interest in the matter among the townspeople in general so that a meeting was called to discuss ways and means for getting a sewer system. The meeting was largely

attended by a variously assorted group of people: people who wanted a sewer system and people who thought they did not, or were not sure; people who knew something about the operation and maintenance of sewers, and people who believed that sewers would do away with the supply of food for the very profitable pigs kept at the town farm: people who might be expected to contribute in varying degrees, out of technical knowledge and experience or out of no knowledge at all, to the solution of the problem.

The meeting's first act was to elect as chairman a man who, as it happened, knew little of sewers from any technical point of view. The chairman called for statements from those who had been active in arranging for the meeting. It shortly became evident, from comments and questions on the part of various members of the audience, that serious misconceptions existed as to the nature and functions of a sewer system. Hence a considerable time was devoted to an explanation, by a man who had a little technical knowledge of sewers, of the benefits which a sewer system might be expected to confer on the town. As a result of this explanation some few persons who had previously objected to sewers merely as sewers were won over to the majority point of view, and the meeting centered its attention on three definite questions: What sort of sewer system ought the town to have? How much would such a system cost? How could the town raise the money to provide such a system? There were present at the meeting no persons qualified to give any immediate answers to these questions. The chairman therefore appointed, in accordance with a vote by the meeting, two committees, of which one was to investigate the nature and probable cost of an appropriate sewer system, and the other was to inquire into the financial resources of the town. The committees were instructed to report upon a certain date, and the meeting adjourned.

Whereupon the members went upon their several ways, except for two groups. The committee members, who had received definite instructions, proceeded to carry their instructions into effect. Certain other members, who had received no instructions at all, found themselves impelled by their own interest in the matter to look independently into the questions of sewers and finance. Then upon the appointed day the group as a whole met again.

This second meeting opened with a report from the committee appointed to investigate the nature and cost of sewers. The committee had, it appeared, been uncertain at the outset as to how to go about its task, but had at length consulted a firm of engineers in a neighboring city. From the office of this firm it had obtained an imposing mass of plans and statistics, on the strength of which the committee recommended to the meeting sewers of a certain type to

be built at a tentatively specified cost. This recommendation had hardly been presented before a member of the audience gained recognition from the chairman and announced that he too had been investigating sewer systems and their costs, and that he had secured from a different firm of engineers what seemed to him radically different proposals and estimates. A heated discussion ensued, culminating at length in a vote to refer the question of plans and costs back again to the committee which had reported on it, with instructions for a more careful search for data.

The second committee, called upon for its report, proved to have no report to make. "The committee did not realize that the time was so short," the chairman said, "and they had unfortunately done nothing in the matter until too late to be able to present a report." Action by the meeting was delayed while various members of the audience made incisive remarks upon the committee's lack of performance. Eventually a vote was passed discharging the original committee and providing for the appointment of a new one. Then this second meeting likewise adjourned, to wait till the one new committee and the newly instructed old committee should have time to obtain the information demanded of them.

For those who must know the ending of every story, it may be said that the town did at length get a sewer system—or the beginning of one, at least. But for present purposes the story of the citizens' efforts to find out about sewers and eventually to provide them for the town need not be set forth in further detail. The account of these two meetings will provide ample illustration of the process of group learning as it normally takes place. That the process in this instance was one of group learning is doubtless sufficiently apparent. The people who assembled at each of these meetings were concerned primarily, of course, not with learning for the mere sake of learning, but with getting a certain thing done. They could not accomplish their purpose without finding out a great deal that they did not know, and they proceeded to find out whatever was necessary. Learning resulted for almost everyone concerned. A statement of the process of arriving at this learning represents, for present purposes, the moral of the story, and may well be considered in detail, as most morals drawn from stories are.

It should be noted in the first place that group learning begins with the encountering of some recognized problem. The problem must be "recognized" not so much in the sense that it can be stated in so many words, as in the much more important sense that it actively perplexes, or troubles, or appeals to the interest, of the persons composing the group. It must, furthermore, be a problem which concerns these persons as a group—a problem which only group action on their part can solve, or which group action can

obviously solve more effectively than can purely individual attack upon it—if it is to remain for long the focus of any group learning. Given a problem of this sort, as in the case of people's concern with their lack of sewers, and group learning shortly begins to occur.

With the problem definitely recognized and the group in a mood to deal with it, certain natural "stages" in group learning almost immediately appear. There is likely to come at the beginning a period of uncertainty as to what the problem involves—the period marked in the matter of the sewers by the effort of the group to remove misconceptions and to focus attention upon the question at issue. Group discussion of the problem, for the purpose of defining it as clearly as possible, represents this particular stage. Next usually comes some such further discussion, as that which led to the appointment of committees—an effort not so much to define the problem itself as to discover methods for going about its solution. And finally appears a decision as to immediate things to be done—in the case of the problem of sewers, the assignment to individual members of the group (the two committees) of special responsibilities in furthering the solution of the problem. In these stages—discussion of the problem in an effort to define it, discussion of methods of solving it, assignment to individual members of the group of things to do in connection with its solution—are comprised the skeleton of practically every situation in which group learning moves economically and effectively to its conclusion.

The moral of this particular story does not end, however, with an analysis of what happened in the first of the two meetings. Group learning can seldom be carried to its necessary conclusion wholly within the group which undertakes it. Individual members of the group—sometimes selected persons, sometimes every member of the group—must discover outside the group meetings things which the group as a whole does not know, in order to further the attack of the group on its problem. Almost always, in other words, there must be a shift from group to individual learning after the group has reached the limit of its progress as a group, and then a transition to group learning again when the results of individual learning have made further group procedure advantageous.

In the matter of the sewers the transition from group to individual learning is, of course, marked by the asssignment of certain responsibilities to committees. The work of these committees, together with the voluntary investigations of individual members of the group, represent a process of individual learning. At its conclusion group learning begins once more, with the attention of the group as a whole centered upon the results of this individual learning.

In the second group meeting the stages of procedure are identi-

cal with those in the first. There comes at the beginning an attempt to define the problem more clearly in the light of new information supplied by a committee—an attempt furthered in the long run, though apparently confused for the time being, by the voluntary contributions from individual members of the meeting. The discussion of methods of advancing the solution of the problem is concerned in the present instance with the further duties of the appointed committees. Ultimately there is a definite assignment of additional responsibilities to the appointed members, and group learning again gives way to individual learning. The procedure to which this second meeting contributes its part is one which alternates back and forth between group and individual attack upon the problem, with the group as a whole defining the problem, suggesting methods for its solution, and imposing responsibilities upon individuals, and with individuals fulfilling their responsibilities adequately or inadequately, supplying a basis in any case for further progress by the group.

This is the process of group learning as it is likely to take place when people come together of their own accord to get something done. Between such a process and the procedure which goes on in the average classroom there are obvious differences. The usual classroom procedure insists on no problem which awakens the interest of the group as a whole—insists, in many cases, on no problem at all, except the obvious and irksome problem of satisfying an authoritative teacher. Classroom procedure gives room for scant discussion of what is to be done or how to do it: tasks are ordinarily defined and methods of dealing with them outlined not *by* the class as a whole but *for* it. Classroom procedure recognizes little or no responsibility on the part of individual students to the group: responsibility is directed from each individual to the teacher, who, in the last analysis, is sole arbiter of excellence and dispenser of praise or blame. The usual classroom procedure brings forth, on the whole, almost exclusively individual learning, motivated by authoritative demands, carried out in terms of dictated specifications, and gauged by largely arbitrary standards, as compared with the very different type of learning to which group coöperation normally gives rise.

To conclude that the usual plan of classroom procedure ought to be supplanted in every particular by a scheme of unguided group learning is, however, hardly justified. Classroom procedure offers, to its possible advantage, at least one feature which most voluntary group learning does not possess—the presence of a person already adept both in what is to be learned and in ways of learning. Using his knowledge wisely, such a person may add greatly to the economy and effectiveness of group learning. Had such a person been pres-

ent at the first of the meetings for the discussion of sewers, for example, and especially had he been chairman of the meeting, he might have foreseen the various misconceptions which arose and might have led the group as a whole to a speedier and more exact understanding of the problem which faced them. He might also have helped to insure against loss of time and energy on the part of committee members, by suggesting the need not merely for instructing each committee as to what its duties were, but for advising each committee as to promising methods of performing these duties. He might have aided in the evaluation of the committee report by pointing out, even in advance of the committee's own investigation, the desirability of securing pertinent data from a variety of sources. The assistance of such a person in defining the problem at issue when the group's own efforts are obviously unsuccessful, in discovering fruitful methods of investigation or sources of data of which the group itself is unaware, in evaluating the learning which results from both group and individual effort, may obviously add measurably to the total achievement both of the group as a whole and of its individual members.

Yet though group learning under skillful guidance may be more effective than most group learning which lacks such guidance, group learning even without guidance has certain noteworthy merits. The fact that it starts always with a recognized problem is of especial advantage, not merely because common recognition of the problem makes for unity of purpose in the group as a whole, but because interest in the problem leads to a positive effort to learn. The fact that the group itself must define its own problem and reach some tangible decision as to methods of attack upon it represents a further advantage, since under these conditions the group learns eventually not merely what the solution to the problem may be, but how to arrive at such a solution. And the fact that individual members of the group are responsible to the group itself represents a third advantage, in that approval or disapproval by the group is likely to furnish the strongest possible incentive to achievement. Whether in acquiring mastery of particular knowledge or habits or skills, or in learning how to acquire such mastery, group learning seems to hold values which cannot lightly be disregarded.

May it not be a fair conclusion, then, that the teaching procedure which offers greatest promise of truly justifying the classroom teacher is one which combines the advantages of group learning with the further advantages of group learning under guidance? Procedure of this sort gives due recognition to each of those facts which the teacher must take into account: that his classroom work requires the teaching of groups of students; that group learning

involves a procedure more or less distinctively its own; that the teacher's own part in teaching is chiefly to be found in the contribution which he can make to group learning. Basing his work upon this conception of his responsibilities, the teacher would, it is true, find his task a more difficult one than that which the average teacher takes upon himself. Yet the outcome of such a task, in terms of things learned by students and of students' interest and their ability to go on learning, is not likely to be duplicated on any other basis.

Were this conception of the process of teaching to be put completely into effect, it would involve numerous and radical departures from the usual methods of class-conduct. It would bring about changes, for one thing, in the teacher's relationship to his class. To provide the conditions under which students might want to learn as a group, to order the situation in such manner that each of the steps of learning might be carried out at the proper time and to the proper degree, to supply the necessary materials and sources of information by which individual learning might contribute to group learning—these would be the teacher's duties under such a procedure. Instead of arbitrarily setting tasks, the teacher would find himself faced with the necessity for interesting his students in the discussion of major problems, for guiding their discussion toward clarification of the subordinate problems involved, for suggesting to them methods and materials which would be of value in the solution of these problems. Instead of presenting formal lectures, it would be the teacher's function to supply merely such information as students could not readily or economically find for themselevs or to give information which would interest them in further study of the problems at issue. Instead of examining, as sole arbiter of excellence, the students' efforts to perform assigned tasks, it would be the teacher's duty to guide discussion by the class itself of the results of such outside work as had significance for the group as a whole. The teacher would become, in effect, stimulator, critic, and guide, rather than dictator or dispenser of knowledge; and the teacher's skill would be measured by his success in getting his students to learn for themselves, rather than by his ability merely to "teach" in authoritative terms.

Were this conception of teaching to be completely adopted, it would bring about changes also in the organization of subject matter. It seems to be an inevitable result of the simplicity and uniformity of usual methods of teaching, that subject matter should be presented as if all of it needed to be acquired, item by item, in the same way by any one student as by any other. Thus all students are required to read the same books, and perform the same exercises, and write the same papers, even though other books or exer-

cises or papers would serve quite as well the purpose for which they are designed. Under the changed conception of teaching, there would logically arise a clear distinction between the fundamental habits or knowledge or skills which the teacher sought to develop, and the means by which those fundamental outcomes were to be reached. The approach to each new problem would still be the same for all. But the problem itself would be recognized as the development of a certain ability or understanding, and the methods adopted for its solution—for the mastery of the ability or understanding in question—might differ as the aptitudes and interests of the students themselves proved to differ. Hence subject matter would be organized in terms of a two-fold classification. On the one hand would be questions for group discussion, with which all students alike would be concerned. On the other hand, leading out of these questions, would be subordinate problems or exercises or study, differing on occasion for individual students, and offering means by which each individual might carry on the individual learning to which group learning paved the way. In an organization of subject matter which contributed to group learning and individual learning, each in its place, as contrasted with an organization which interpreted all subject matter as appropriate only for individual learning, would be found one of the most radical changes which the new conception of teaching would bring about.

Were this conception to be completely adopted, it would bring about further changes in the formal ordering of class work. Class meetings of uniform length, scheduled for fixed days in the week and for a fixed total of periods-per-semester, would obviously find slight justification in a plan in which the nature of a problem under discussion should determine the methods of study to be pursued. Laboratory work organized on a similarly arbitrary and inflexible basis would likewise have to give way to a more flexible procedure. Outside study assigned in measured amounts, alike for all students, would form no defensible part of the plan. In contrast with these systematically mechanized arrangements by which administrative "justice" is done to students and teachers alike, class discussions and demonstrations might occupy several class-meetings, with no intervening assignments to individuals; individual laboratory work would presumably follow upon group discussions, instead of paralleling them independently; class-meetings and laboratory periods both would extend over longer or shorter periods of time, depending on the nature of the work which they involved; outside study would be assigned somewhat irregularly, whenever it might be needed for its contribution to class discussion or laboratory work.

The mechanics of learning, that is to say, would be at every step duly subordinated to the demands of the learning itself.

If this conception of teaching were to be completely adopted, our system of education would, in other words, be very different from that which is now in existence.

Yet it is perhaps only too obvious that no one can reasonably look forward to any such fundamental revision as this conception might seem to imply. However desirable it might appear to everyone concerned that the projected scheme of teaching be put into effect, its complete adoption either now or in any near future would be inevitably prevented by at least three overwhelming obstacles: by the nature of people in general, by the limitations of students, and by the life-long experience of teachers. There must be concessions to all three of these obstacles if a workable procedure is to be evolved.

The concession demanded by the nature of people in general applies to the administration of the scheme. People seem to be so constituted that their activities must be systematized in order to be successful. Hence the assignment of fixed hours to classes and laboratory work and outside study cannot be carelessly thrown aside. Deplorable though an arbitrary arrangement of schedules may be from the standpoint of pure educational theory, it is probably a necessary condition of systematic education, and must therefore be taken into due account.

The concession which must be made to the limitations of students is less permanent, perhaps, than that concerned with the scheduling of classes, yet it strikes even more directly at the root of the scheme. Students have been trained to work under usual classroom methods. They come to any new scheme of teaching quite unfitted by their previous schooling to avail themselves of more than a few of the advantages which such teaching may offer them. As they become accustomed to the new demands made upon them, they may be expected to respond with increasing assurance and with growing benefit to the new type of teaching. But their adaptation to radical changes in method must necessarily be slow; so that at least at the beginning, there can be no sudden shift from old to new.

The concession which must be made to the life-long experience of teachers is still more fundamental than that demanded by the limitations of students. Brought up under traditional methods of teaching and trained formally or by their own habits into an approximation of these same traditional methods, teachers can seldom free themselves sufficiently to meet the full demands of a radically different plan. They find themselves bound down in part to a certain way of thinking about their own place in the classroom, which

makes it difficult for them, in the case of the suggested procedure, to surrender a traditionally autocratic position for one more appropriate to group learning. They find themselves bound down also to a certain way of thinking about the subject matter which they teach. It is particularly hard for many teachers, apparently, to envisage the essential distinction between subject matter which lends itself to group learning and subject matter which is appropriate to individual learning. Even when the distinction itself is clear, teachers frequently encounter a further difficulty—perhaps, to tell the truth, an insurmountable one with certain types of subject matter: they do not see how to make group learning lead into individual learning, or how to relate students' individual learning to problems of value to the group as a whole. The experience of numerous skillful teachers in various fields of subject matter makes it seem probable that these difficulties are by no means insuperable ones, even though they loom large in the eyes of teachers who attempt an abrupt change in their methods. Hence, like the concession which must be made to the limitations of students, the concession which each teacher must make to his own inability to change himself may be expected to grow less as his experience with the proposed plan of teaching develops. Yet it obviously represents at the outset a major restriction upon the adoption of the suggested methods.

In spite of these obstacles to its complete adoption, however, the proposed plan is by no means devoid of practical value. To the extent to which it can be put into even piecemeal effect, it is likely to bring about an improvement in the quality of classroom teaching. And parts of it can be put into immediate and important effect. Though the average teacher cannot change his hours of teaching or the general allotment of his students' time, he can make various modifications both in what he demands of his students and in the procedure he adopts for himself.

He can, for example, devote his class-meetings to discussion with his students—not lectures to his students—of problems which perplex or trouble or interest his students. He can introduce, for this purpose, problems which admit of profitable group discussion—problems which are unsettled as well as unsettling from the students' point of view. He can select these problems, and guide his students' discussion of them, in such a way as to promise not merely broader understanding of important subject matter, but an increasingly greater ability to deal with problems of various sorts.

He can reduce to writing and make available in printed form the type of information which forms the basis for traditional class lectures. By so doing he may increase the economy and effective-

ness of his students' approach to their individual study, and may at the same time secure added class-periods for profitable group discussion.

He can recognize his laboratory periods, and if necessary certain of his class-periods, as periods for individual learning, and can encourage his students to use them accordingly. Thus he can keep his more formal class-meetings intact for the purpose which they alone can serve—the guidance of group learning.

Through group discussions of what is to be done and how it is to be done, he can pave the way for his students' attack upon each new unit of study or laboratory work which involves new materials or new methods.

He can so organize his teaching that each assignment of laboratory work and outside study is based upon problems related to those being treated in current class discussions, and he can encourage his students to draw upon each phase of their work for its contribution to the other phases.

He can present each part of his course—those parts which involve largely individual study, as well as those parts organized in terms of problems for group discussion—in such manner that his students will see its significance and its value.

He can do all these things at least. If he is sufficiently skillful and his students are able and the conditions of his work are sufficiently flexible, he may find it possible to do more than this. But even if these things and nothing further represent the extent of his accomplishment, he will have established for himself a plan of procedure which goes far beyond traditional method. With a plan of this sort as the basis of his teaching, it seems safe to predict that he need have little fear of competition from mechanical systems or devices, nor of his own ability to justify his job.

CAN INDUSTRIAL ENGINEERING BE TAUGHT? *

By ALLAN H. MOGENSEN

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As I understand it, I am here today to justify Industrial Engineering. This is in answer to the Wickenden Report, which discouraged the teaching of industrial engineering subjects and advocated teaching certain subjects in the field of economics and business administration, offering this as an elective to engineering students. I am not going to attempt to do this. In the first place, ever since I read the article, "The Engineer and the Intellectual Life," by Palmer Ricketts, I cannot forget his opening remarks. He said: "Not long ago it was suggested that I write an article on engineering education, but I do not feel competent to do so. I have had only 54 years of experience in this branch of science, and feel that I should leave advice on this subject to those more experienced, and perhaps more dogmatic." So what chance has a mere youngster like myself to pass on a subject of such weight. Also, as this is a meeting of the Society for the Promotion of Engineering Education, I assume that you are all teachers of industrial engineering, or industrial engineers, or possibly even both. In addition this is a sectional meeting devoted to the subject of industrial engineering. For these reasons it seems futile for me to try to tell you why I think the man trained in industrial engineering is better suited for executive and managerial positions than the graduate of the school of commerce. This controversy was very well answered some years ago at a meeting of the Taylor Society in a session devoted to consideration of this problem by the teachers of management. Therefore, I am going to bear heavily on the presentation of the general aims of industrial engineering curricula, and on the needs for men trained in this line by industry.

I shall first give you some results of the questionnaire sent out by Hugo Diemer, who by the way should be giving this talk this morning. Colonel Diemer is chairman of the committee on education of the Society of Industrial Engineers. The results of the survey made by his committee will not be made public until the October meeting of the Society of Industrial Engineers in Washington, but I can give you a few of the outstanding results now by going through it hurriedly. The institutions reporting a distinct

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curriculum, and granting a distinct degree in industrial engineering or industrial management, are 17 in number, one giving a degree of Industrial Engineer, 9 the degree of Bachelor of Science in Industrial Engineering, 3 the degree of Bachelor of Science in Industrial Management, 1 the degree of Bachelor of Science in Administrative Engineering, 1 the degree of Commercial Engineer, 1 the degree of Bachelor of Science in Management, and 1 Bachelor of Science in Industrial Shop Administration. The institutions reporting a distinct curriculum in industrial engineering, or industrial management, but not granting a distinct degree, are 10 in number. These degrees are given as Bachelor of Science in Mechanical Engineering, Bachelor of Business Administration, Bachelor of Science in Engineering, and Bachelor of Science in Engineering Administration, so that the total number of institutions reporting distinct curricula in industrial engineering or industrial management were 27. The institutions offering organized sequences of studies in industrial engineering, or industrial management, these sequences or groups acting as functional or service departments only, and not offering a separate curriculum, were five in number altogether. Seventeen institutions reported that they have no organized sequence of studies in industrial engineering or industrial management, and under this classification the number of options available to engineering students in economics or business administration ran all the way from 1 to 33. When asked the question, "Would you recommend an organized sequence in industrial engineering or industrial management?," six had no comments, four said "Yes," three "No," and one doubtful.

In speaking of industrial engineering, industrial management, and business administration, we come, of course, to the question of definition. So many have been given that I am not going to attempt to formulate one here. I should, however, like to read the definition of Industrial Engineering which was sent in on one of the replies to the questionnaire. The catalog of Lehigh University defines industrial engineering as follows: "Industrial Engineering has to do with the organization, operation and management of manufacturing plants, public utilities and operating holding and managing companies. Broadly considered, it covers the engineering aspects of plant location, plant layout, routing, production control, maintenance, stores and inspection, the economic aspects of employment, employee training, promotion, wage payment, bonus, safety and welfare, insurance and old-age pension and commercial aspects of purchasing marketing, credits, accounting and finance." New branches of management or engineering are opening every day. No doubt you have heard the latest, the so-called "intestinal" management.

It has been found that three-quarters of the graduates of engineering schools eventually occupy administrative positions, and yet in Mr. Wickenden's own report he states that less than 10 per cent. of the production executives are college trained men. Bradstreet reports that of the business failures last year, 80 per cent. were due to incompetence in one form or another, and it is known that less than 10 per cent. of industrial firms have real knowledge of cost. What do all these figures mean? What do they prove? I feel that they show a real need for the trained industrial engineer in industry, and despite the business depression you will all probably concur with me in that your graduating class in industrial engineering has had no difficulty in securing positions.

Recognition of the industrial engineer is slow in coming. He will have to overcome the same inertia that was encountered several generations ago, when the mechanical engineer tried to demonstrate that there was another kind of engineering beside military and civil. When the Kemmerer Finance Commission was organized to go to Poland in 1926, at that time there was no thought of including an engineer. Despite the great opposition, however, Wallace Clark, the outstanding industrial engineer, was selected, and if you doubt for one moment the value of his work on that commission, read the report. His work was so well appreciated that he was called back the following year, and now spends most of his time abroad, and has offices in Warsaw, Paris and Prague. He has been working in paper mills, pulp plants, automotive and alarm factories, steel and brass mills, car shops, and numerous other enterprises. I could go on at length about him and his work, but can only here say that Wallace Clark is doing an excellent job of industrial engineering abroad, and they are coming to appreciate the value of industrial engineering through his efforts.

Let us consider some of the things that have been done by industrial engineers and management engineers in industry, and some of the things that will have to be done. First of all, there has been a pronounced tendency toward a better understanding of time study. The time study sessions of the Society of Industrial Engineers have attracted record attendance. The committee on time study has done a fine job, and expects to have a book out before long. The Taylor Society meetings in Detroit in 1928 were devoted entirely to this subject. The A.S.M.E. time study conference, at their annual meeting a few years ago, attracted a large crowd, and this year the annual meeting of the Taylor Society had on its program an excellent paper by King Hathaway, in which he covered the subject briefly, as he said, in a four-hour paper. At the American Management Association meeting in Cleveland the beginning of this month, announcement was made of the forma-

tion of a new division to cover this field, called the Shop Practice Division, headed by the man in charge of time study at Goodrich Rubber Co. It gives me a good deal of pleasure at this time to inform you that the Detroit Society of Time Study Engineers has just been combined with the Society of Industrial Engineers, so that together the resources of the National Society and the intense interest and hard work of the Detroit group may result in placing this phase of industrial engineering where it rightfully belongs. By time study I do not mean what is commonly known as time study, which is merely rate setting. Naturally, some teachers of industrial engineering or industrial management hesitate to teach this subject when it involves merely a mechanical reading of a stop watch, taking the operation as it is. And, unfortunately, in too many of our engineering schools that phase of time study is all that is taught. I think we feel, and a good many plant men feel, that they should not find it necessary to turn to a university graduate for a mere rate setter. Within the past few months time study has taken on an entirely new aspect throughout the country. People are coming to realize that time and motion study is not a laboratory method adaptable only to certain few particular operations. I wish I had more time to tell you some of the things that are being done in applied motion study at the present time. Outstanding is the work that is being done in Detroit. A few years ago they considered micro-motion study absolutely useless as far as they were concerned. It was all right, they said, for Mrs. Gilbreth, and some of her followers, to make laboratory studies where there were a large number of operators affected doing repetitive work. Their work was different, and until fairly recently, you will have to admit, time study was considered out of the question in the automotive industry. But now, led by Cadillac Motor Car Co., the whole automotive industry is sitting up and taking notice. Mr. Ralph Blakelock, of General Electric, spoke in Detroit on applied motion study, and the effect this had upon the men in time study work has been nothing short of marvelous. Real time and motion study work is going forward, micro-motion laboratories have been set up, and if you get a chance to visit Detroit you must look in on this experiment. Set up in the laboratory are various simple operations showing the old and new methods by application of certain fundamental principles of time study. No equipment has been purchased, and very little money spent. Time study men, foremen, superintendents, supervisors, jig, die and fixture designers and builders, have been brought in and instructed in this subject. These men then go back into the plants and apply these principles to their own work. The results have been tremendously far-reaching. Each workman in the plant is applying these principles.

(The speaker then described in detail a few of the studies being made at Cadillac with the aid of diagrams on the board, and explained some of the motions.)

Now these studies are not going to make the Cadillac car cheaper immediately. The simple study made on the license brackets will not reduce the cost of this car. However, the principle that applies entirely throughout the plant, wherein every foreman, every workman, supervisor, machine designer, and tool designer is thinking in terms of motion and methods, will have a far-reaching effect. This work is just being started, and no one can say where it will end. Some few of you have already adopted the motion picture camera in your class-room work for teaching this subject. In my work at the University of Rochester I felt that the teaching of time and motion study was very important. I felt that it gave the engineering graduate a definite foothold in industry. He then could go out and compete on a financial basis with his fraternity brothers who are bond or insurance salesmen, and feel that he was earning a fair wage. I know of no other work anywhere which will give a man as much insight into human relations, give him as many opportunities to study methods and processes, and definitely decide where we wants to go in industry. I emphasized this teaching, fitting the graduates of the course for good positions as time study men. Very few of them expect to remain time study men, and I am sure that none of them will ever regret this training. I hope that all of you will find it to your advantage to look into this matter, and I hope Professor Porter will, a little later, be able to tell you some of the things that he has been doing with this work at New York University.

Then, in the sales field there is an increasing tendency toward the use of facts as the basis for policies and methods. This is largely due to increased buying intelligence on the part of the public. High-pressure methods and empty oratory are passing out. The conventions of sales managers, and of various trade associations, indicate an increase in the scientific selection and training of salesmen. In market surveys and analyses, and the tie-up of sales management with production, we have the scientific method of approach finding application. No longer is the map taken out and blocked off in rough approximations, and divided into sales territories. No longer are equal sales efforts applied to all fields. No longer is a product handled in the same manner and by the same men. These analyses and surveys enable business to sell as efficiently as it produces. Bankers are beginning to rely more and more on the industrial engineer and his advice. Condition of an industrial establishment, and the granting of unsecured credit, is now submitted to the industrial engineer for his counsel. The ac-

curate facts and figures that are used as a basis for the granting of credit consist of the balance sheet, indicating the present financial status, the profit and loss statement, indicating past performance, and the budget to control future performance. In the old days if a concern wanted to borrow money the ratio of assets to liabilities was investigated. If this was 2 to 1 it was considered satisfactory and the loan was made. If not, they could try all they wished, but in most cases they would not receive the loan. Now the bank has an industrial engineer who goes into the plant and makes a survey more thorough than that made by the average consulting engineering firm. He then passes on the plant's justification for the loan.

The importance of budgeting has been demonstrated recently. The comptroller of one concern has been described by C. E. Knoeppel as one of the men deserving his title of supercomptroller. This man makes up his budgets starting the first of September for the following year. Last year, after the budget was well under way and the crash came, the executives thought perhaps they had better retrench a bit. The comptroller, however, said "No, we will advertise where we have not been advertising before, and advertise more extensively where we have been advertising." As a result of this, you have seen this company's advertisement in two-page spreads and in new media ever since that time. In a business involving a tremendous number of items in tremendous varieties and large quantities, they were, at the end of 1929, within 2 per cent. of their budgeted figure. So far in 1930 there was no curtailment or reduction in the original plan. They are within one-half per cent. of their estimated figure. This concern issues a monthly profit and loss statement twelve months in advance. These new methods of cost control I believe will be the answer to the success or failure of business in times such as we have had in the past few months.

Proper cost analysis has for its basis predetermination and forecasting. You are no doubt familiar with some of the cost control charts used for controlling fluctuating production costs. These costs range all the way from very simple charts, showing cost per mile of operation of your automobile, to very complicated boiler plant operation costs. (The speaker then described and illustrated the hyperbolic cross-section paper, and showed how this could be applied to solution of cost problems.)

Likewise, the method of scientific solution can be applied to the question of inventory control. No longer does the subject of hand-to-mouth buying, and the question of proper inventory, offer the problem it once did. Professor Raymond, of the Massachusetts Institute of Technology, and Professor Davis, of General Motors

Institute, have developed a very satisfactory formula for the solution of these problems. (The author then discussed and showed by illustrations on the board economic lot size and economic minimum purchasing quantity formulæ.)

Lastly, we come to the question of profit control. To my mind, this is by far the most important problem confronting business at the present time, and should be without question given in detail to the industrial engineering student as part of his equipment before graduation. (The speaker then described in detail the profitgraph, drawing this on the board, and explaining the various points and illustrating as he went along.) The General Motors and other figures well illustrate the value of profit control. Dean Kimball, in "Modern Industry and Management," in the book "Toward Civilization," says, "Even more important than the basic principles, specialized labor and the extended use of labor-saving and time-saving apparatus, have been the influence of scientific and engineering methods of thought upon all ideas of management and business. As the background of industry has become increasingly more scientific, the technically trained man has assumed a leading part in industrial management. If the present trends continue there will be little place in the field of management for those unacquainted with engineering technology. These technically trained men have naturally brought their accurate methods of thought to bear on management problems. The old methods of management, which, unfortunately, still prevail in many places, are almost wholly empirical and based upon personal judgment. The engineering methods consist of finding out first what the facts of the problem may be as the basis for the use of judgment. The most profound effect of engineering thought upon managerial efforts sprang from the ability of the engineer to predict with certainty the performance of his product. He quite naturally has tried to apply analytical methods to the prediction of the time and sequence of industrial operations, and to predict in advance how, where and when the productive operations in which he is interested should be performed. To sum up then, let me say, controlled management means the kind of management in which all actions are based on judgments guided by facts which have been intelligently interpreted and simply presented in the same way that the ocean vessel is piloted by management who is continually making soundings, observations, calculations and charting its facts, after which decisions are made with reference to the actions to be taken."

Now, before I close I want to emphasize that I am not saying that the slide rule and the chart are going to take the place of brains. Nothing is further from my mind. No matter how well a man is trained in the technique of operation, a few of which I

have mentioned briefly here, he must be able to apply these properly, he must know when to use this one, and when to use that one. However, I do feel that the trained engineer, with his engineering method of approach to every problem, and his scientific solution, is needed more by American business today than ever before. We are coming to the point where we are beginning to question a man's right to set up in business. In the past too many people utterly unqualified to operate a business have been permitted to do so. The tremendous number of failures attest to this. Good judgment and common sense, together with experience, backed with an absolute knowledge of facts, are essential. It is up to us to give our engineering graduates these tools.

NEW MEMBERS

ADAMS, ARTHUR S., Associate Professor of Mechanics, Colorado School of Mines, Golden, Colo. R. W. Morton, R. A. Baxter.

BALL, THEODORE R., Associate Professor of Chemistry, Washington University, St. Louis, Mo. A. S. Langsdorf, E. O. Sweetser.

BARNARD, NILAS H., Professor of Mechanical Drawing, Tennessee Polytechnic Institute, Cookeville, Tenn. E. G. Young, E. C. Schmidt.

CHERRY, FLOYD H., Associate Professor of Electrical Engineering, University of California, Berkeley, Calif. H. B. Langille, F. L. Bishop.

CLOKE, PHILIP R., Evaluation Engineer, Day and Zimmerman, 3227 Spring Garden St., Philadelphia, Pa. Paul Cloke, R. L. Sackett.

FORRESTER, GLENN S., Personnel Division, E. I. duPont de Nemours Co., Wilmington, Del. R. I. Rees, O. W. Eshbach.

GOVIER, CHARLES E., Professor of Electrical Engineering, Pennsylvania State College, State College, Pa. C. L. Kinsloe, L. A. Doggett.

GRANT, ROBERT J., Assistant Professor of General Metal and Auto Mechanics, State Teachers College, Oshkosh, Wis. Frank W. Walsh, F. G. Higbie.

HEFFNER, ROY J., Educational Director, Bell Telephone Laboratories, 463 West St., New York City. G. B. Thomas, John Mills.

JAMISON, WALTER W., Head, English Dept., Mass. School of Art; Instructor in English, Massachusetts Institute of Technology, Cambridge, Mass. F. G. Willson, E. D. Kingman.

LARKINS, JAMES T., Assistant Professor of Engineering Drawing, Pennsylvania State College, State College, Pa. A. L. Tobias, A. S. Jones.

MATLOCK, JOSEPH R., Instructor in Civil Engineering, Oklahoma University, Oklahoma City, Okla. J. F. Brookes, J. H. Felgar, N. E. Wolfard.

MCGIVERN, JAMES G., Instructor in Drawing, Northeastern University, Boston, Mass. L. F. Cleveland, E. F. Tozer.

MEIKLE, G. STANLEY, Director, Research Relations with Industry, Purdue University, Lafayette, Ind. A. A. Potter, W. A. Knapp.

MIDDLEMISS, ROSS R., Assistant Professor of Mathematics, Washington University, St. Louis, Mo. A. S. Langsdorf, F. L. Bishop.

MURAT, SALIH, Professor of Physics, Robert College, Constantinople, Turkey. L. A. Scipio, Ed. S. Sheiry.

ROBERTSON, BURTIS L., Assistant Professor of Electrical Engineering, Pennsylvania State College, State College, Pa. R. L. Sackett, L. A. Doggett.

SCHELVANOFF, SERGEI A., Member, Technical Staff, Bell Telephone Laboratories, 463 West St., New York City. T. C. Fry, John Mills.

SIROKY, EDMOND, Associate Professor of Applied Mathematics, Washington University, St. Louis, Mo. A. S. Langsdorf, E. L. Ohle.

TEBO, FRANK A., Instructor in Engineering Drawing, Pennsylvania State College, State College, Pa. A. L. Tobias, A. S. Jones.

THAYER, HORACE R., Assistant Professor of Engineering Drawing, Pennsylvania State College, State College, Pa. A. S. Jones.

TUBINI, BERNARD A., Professor of Electrical Engineering, Robert College, Constantinople, Turkey. L. A. Scipio, E. S. Sheiry.

TYMSTRA, SYBREN R., Instructor in General Engineering, University of Washington, Seattle, Wash. F. M. Warner, E. R. Wilcox.

WILSEY, EDWARD F., Professor of Physics, Robert College, Constantinople, Turkey. L. A. Scipio, Ed. S. Sheiry.

THE T-SQUARE PAGE

FREDERIC G. HIGBEE, *Editor*

OBJECTIVE STANDARDS FOR GRADING LETTERING DONE BY ENGINEERING STUDENTS

During 1928, Dr. Clair V. Mann, Chairman of the Research Committee of the Engineering Drawing Division, undertook a study of freehand lettering done in engineering colleges of this country. A brief report of the study was made in the Journal of Engineering Education, June, 1929, pages 979 to 992.

Fifty samples of student lettering on standard cards were collected from each of fifty schools. The cards indicated exceedingly wide differences in:

(1) Importance placed upon teaching of lettering. Some schools of highest standard regarded lettering as so unimportant that none was executed in ink. One school returned lettering executed by a senior student which included words *written in ordinary script* of exceedingly poor quality. This card had been graded 75 per cent.

(2) Character of letter forms taught. About half of the schools follow closely "Reinhardt" ("Engineering News") style and standards of lettering. The remainder have indefinite standards, and certain schools taught letter forms which, with "Reinhardt" standards as a basis, would be considerably distorted.

(3) Standards of grading. The staff of each school graded a single card of lettering provided. Eighty-nine instructors graded the card, results ranging from 75 per cent. to 95 per cent.—average, 89.28 per cent. The same card was graded 88.8 per cent by fifty institutions or staffs involved. 89 per cent. would appear to satisfy both institutions and instructors. Standards of institutions which assigned a grade of 75 per cent. to the card were far from average.

Several definitely measurable characteristics of lettering have been selected which can be used in objective grading of lettering, as:

(1) Consistency of style.

(2) Size. (Uniformity in the size of the letter forms; ratio of height of lower case to upper case letters; intervals between horizontal guide lines.)

(3) Slope. (Adherence to specified slope, 2:5.)

(4) Letter shapes.

(5) Character of stroke. Using the same pen, three different types of strokes are made by students: (*a*) the light uniform stroke; (*b*) the heavy uniform stroke (made by bearing down more heavily on the pen); (*c*) the non-uniform stroke, varying throughout each letter from light to heavy stroke.

(6) Spacing. (Letters within words, words in sentences, sentences on page.)

(7) Letter forms, in themselves correct, not uniformly placed on horizontal guide lines.

DIVISION OF CO-OPERATIVE ENGINEERING EDUCATION

The American industries have expanded at an unprecedented rate, which has produced an urgent demand for executives and supervisors. These leaders are called upon to make rapid analysis of a mass of information, come to a definite conclusion, and immediately set in motion the machinery to produce the desired result. They must be men of alert mentality with confidence in their conclusions and with courage to act upon them. The very nature of the instruction and training in engineering colleges promotes just this kind of mental activity—accurate analysis, definite conclusions and immediate action. But the training of an engineer by the usual educational method confines this process almost entirely to materials while an executive must be trained to apply these methods to human beings.

The Co-operative plan affords the student a chance to try these engineering principles upon situations dealing with human beings. His contact with workmen and foremen early brings to his attention the fact that the good executive must not only be proficient in applying the principles of engineering to all sorts of situations but he must also have a personality which demands respect and loyalty. The student sees the need of developing his own personality as well as his mental powers. If he shows that he has more than the ordinary amount of supervisory talent he is given greater and greater responsibility with the result that at the end of his course he has secured a training not only in the solution of engineering problems dealing with materials, but also with the more difficult problems which deal with those more awkward variables, human beings.

By the Co-operative plan, therefore, it is possible early to discover those students who possess native supervisory ability and to give them some training as executives. This training is elementary, to be sure, but it is none the less effective

W. H. Timbie.

THE LAMME MEDAL FOR ACHIEVEMENT IN ENGINEERING EDUCATION

One of the outstanding results of the recent study of Engineering Education, under the direction of Dr. Wickenden, is a realization of the fundamental importance of good teaching. Buildings, equipment, curricula and heredity count. They, however, are secondary considerations in the promotion of Engineering Education to the enthusiasm, creative interest, ambition and self starting initiative which can be generated in the otherwise average student, by a good teacher.

Realizing the importance of good teaching, the late Benjamin G. Lamme, through his will, has made it possible for the Society for the Promotion of Engineering Education, by the award of a medal, to recognize each year some outstanding accomplishment in technical teaching or some significant advancement of the art of technical training.

George Fillmore Swain of Harvard University, Irving Porter Church of Cornell University, and Charles Felton Scott of Yale University, have been so recognized by the Society.

The members of the Committee on the Lamme Award wish to express their appreciation to the members of the Society for the helpful suggestions which they have made and for the many expressions of approval.

No formal blank requesting your suggestions of those qualified for the Lamme Award will be sent out this year. The Committee, however, would like to have your further cooperation. An informal note suggesting the name of the technical teacher whom you would choose for the 1931 Award together with your reasons for the choice will be appreciated. Please address the Committee in care of Miss Nell McKenry, Assistant Secretary, Society for the Promotion of Engineering Education, University of Pittsburgh, Pittsburgh, Pennsylvania.

COLLEGE NOTES

Antioch College.—In Dean Ayres' interesting article on schools of engineering employing the co-operative plan, which appeared in the November number of the *Journal of Engineering Education,* Antioch was not mentioned. I am giving the Antioch data that correspond with that presented in the November number:

1930	*1925*
Years required—6.	Years required—6.
Co-op. work begins—1st year.	Co-op. work begins—1st year.
Length of alternating periods—5 weeks or 10 weeks.	Length of alternating periods—5 weeks or 10 weeks.
Total co-op. time—151 weeks, maximum.	Total co-op. time—151 weeks, maximum.
Total school time—120 weeks.	Total school time—120 weeks.
Ratio co-op. school weeks—1.26.	Ratio co-op. school weeks—1.26.
Total co-op. enrollment—566.	Total co-op. enrollment—569.

The engineering department was established in 1922.

The Clemson Agricultural College.—Appointments and promotions in the Engineering faculty in the year 1929–30 include the following: S. R. Rhodes, Professor of Electrical Engineering, promoted to head of the department of Electrical Engineering; D. D. Curtis, formerly Assistant Professor of Mechanics and Hydraulics at the University of Iowa, Professor of Mechanics in charge of Mechanics and Strength of Materials; D. H. Shenk, formerly Instructor in Mechanical Engineering at Purdue University, Associate Professor of Mechanical Engineering.

Appointments to the faculty for the current year include F. T. Tingley, formerly Instructor in Electrical Engineering at the University of Illinois, Professor of Electrical Engineering; C. M. Asbill, Jr., formerly with the Westinghouse Company, Assistant Professor of Electrical Engineering; C. P. Philpot, formerly Instructor in Industrial Arts at Georgia Military College, Instructor in Mechanical and Electrical Engineering; P. M. Pafford, recently graduated from Georgia Institute of Technology, Instructor in Mechanical Engineering Laboratory.

J. H. Sams, Jr., Instructor in Mechanical and Electrical Engineering, is on leave of absence for the year 1930–31, doing graduate work in Mechanical Engineering at the University of Michigan.

In the Electrical Department, old equipment has been replaced by modern machines until up-to-date apparatus is available for

instruction in all major lines. Special attention has been given to the development of a standardizing laboratory, and a radio laboratory. A good deal has been done along the line of automatic control apparatus, and a start has been made on a high tension laboratory.

In the Mechanical Department numerous additions to equipment have been made. Noteworthy among these is a refrigerating plant unusual in that it has means of weighing ammonia used. An internally fired boiler is available for test work and for an auxiliary steam supply. In hydraulic work instruction in the use of various measuring devices is made convenient by the tandem placing in a line of a venturi meter, an orifice meter, a weir box with four types of weirs in series, a Bailey weir meter of recording and integrating type, and a large weighing tank.

In the Engineering Shops, the usual work is supplemented by good equipment for welding and for heat treatment.

Recently the Civil Engineering Summer Surveying course has been aided by the donation of 16 acres of land in the lower part of the State, for the construction of a permanent camp. The camp is located in a region that is little cultivated and sparsely timbered so that highway or railway practice location survey lines of several miles length may easily be run. Located on a paved highway, overlooking a small lake with good bathing facilities, the camp is ideally situated. The citizens of Batesburg, who were the donors, named the site "Camp Clarke" in honor of Professor E. L. Clarke, head of the Department of Civil Engineering, who has had active charge of the surveying courses.

In instituting a summer camp for field practice in surveying, Clemson College takes the lead of Southern engineering colleges.

Enrollment in Clemson College is limited by the space available in the barracks, and every fall a considerable number of applicants has to be refused admission. By rearrangement and addition of facilities, this year about seven per cent. more students were accepted. The interest in Engineering is shown by the fact that the increase in number of student engineers is twelve per cent.

The **Massachusetts Institute of Technology** has adopted a new index scale of a student's performance. An average rating is computed by assigning the following values to the various grades and weighting by units:

Honor	=	5
Credit	=	4
Pass	=	3
Low pass	=	2
Failure	=	1
Low failure	=	0

A student who falls below 1.40 in his term rating by this scale disqualifies himself and is dropped at once. Consideration will be given to the case of any student, when unusual non-academic causes, such as continued illness, have prevented him from performing his work.

If he falls below 2.00 during the first year, or 2.20 any term thereafter, he puts himself on probational status. He also goes on probation if his cumulative rating after the first year is below 2.15 to 2.50, depending upon the number of terms he has been in residence, unless his current term rating is above 2.20 to 2.70.

If a student goes on probational status for two successive terms, or for three total terms, he disqualifies himself and is required to leave the Institute.

These actions are automatic. In all cases, however, students and staff have a right to present facts to a Committee of Appeal who may waive the rules in exceptional cases.

This scale was adopted to control the quality of training afforded by the Institute:

1. By eliminating immediately the student who completely neglects to take advantage of his educational opportunities as indicated by an unusually low term record.

2. By warning and eliminating eventually the student who previously has been doing satisfactory work but who is now failing through lack of ability or loss of interest.

3. By warning and eliminating eventually a student whose cumulative performance is below a required quality.

4. By providing means for giving further opportunity to the student whose cumulative record is below standard but who is now improving.

Purdue University.—Rapid development of research work at Purdue University in connection with the industrial growth of the state, was emphasized here with the filing of articles of incorporation of the Purdue Research Foundation. The organization of the Foundation, marks another epoch in the influence of the University and gives a new impetus to the extensive research program of scientific research already under way on the campus of Lafayette.

The Foundation is a non-profit organization and has no capital stock. Its prime purpose is to assist in the financing of the research projects and handling of matters pertaining to inventions and patents for the benefit of the state at large, the University and industrial organizations directly concerned.

Calls upon the University by industries of Indiana especially during the last few years, for assistance in solving scientific prob-

lems vital to their growth have increased with the growing economic importance of the state in national affairs. Recognizing the need for more constructive coöperation the board of trustees of the University in 1927 authorized organization of a special department to handle research relations with industry. G. Stanley Meikle, a well known consulting engineer, was chosen director of the newly created department. As a result of this work, direct coöperation between industry and the University has grown rapidly. This has led to the organization of the foundation to assume the legal and financial responsibilities of the rapidly expanding research program.

The board of directors for the Foundation represents the founders, the board of trustees of the University, Purdue alumni, and the national engineering and research councils.

SECTIONS AND BRANCHES

The Middle Atlantic Section of the Society for the Promotion of Engineering Education held its annual winter meeting at Drexel Institute, Philadelphia, on Saturday, December 6th, 1930.

The morning was featured by most interesting inspection trips to the R. C. A.-Victor Corporation at Camden, N. J., and the new terminal and power house of the Pennsylvania Railroad at West Philadelphia. On returning to Drexel Institute the delegates were served a delicious complimentary buffet luncheon by the Home Economics Department of the Institute.

President C. R. Richards called the meeting to order at 2:30 P.M. and introduced Mr. J. Russell Duane, who spoke most interestingly on certain phases of the life of Benjamin Franklin. Dr. H. C. McClenahan, secretary of the Franklin Institute, addressed the meeting on the subject, "The Franklin Memorial Museum of Philadelphia," the construction of which is planned to start within three or four months. Professor W. T. Spivey, in charge of the Drexel Evening School, spoke on "Intermediate Technical Training."

After a brief survey of the laboratories of the Institute, the delegates assembled in the Picture Gallery at 6 P.M. for dinner and a brief business meeting. The nominating committee, composed of E. H. Rockwell, Lafayette; J. W. Barker, Columbia; and O. W. Eshbach, A. T. & T. Co., presented the names of Director S. S. Edmands of Pratt Institute for President, and C. G. Thatcher, Swarthmore, for Secretary and Treasurer, for the ensuing year. These nominees were elected.

It was voted to accept the invitation of Pratt Institute for the 1931 spring meeting. The report of the Committee on Resolutions was as follows:

> Resolved: That the Middle Atlantic Section of the S. P. E. E. assembled for its Fall Meeting at the Drexel Institute, Saturday, 6th December, 1930, desires to express its deep sense of appreciation to the Faculty and Trustees of the Institute for their generous hospitality, and for the very interesting program arranged for our entertainment.
>
> We also wish to express our thanks to the Pennsylvania Railroad and to the R. C. A.-Victor Corporation for the courtesies and privilege extended to us on this occasion.
>
> L. P. ALFORD,
> F. H. CONSTANT,
> W. S. AYARS, *Chairman.*

This report was unanimously adopted.

After a short entertainment by Mr. T. A. Daly, who recited a number of poems in dialect, the meeting was adjourned at 8:10 P.M.

CHARLES G. THATCHER,
Secretary.

The **New England Section** of the Society for the Promotion of Engineering Education held its fall meeting on Saturday, November 1st, as the guests of the Thayer School of Civil Engineering at Dartmouth College. The morning session was opened at ten-thirty by Dean Cloke and an address of welcome was delivered by Craven Laycock, Dean of Dartmouth College. This was followed by an address by Professor William R. Gray, Dean of the Tuck School of Administration and Finance, on the "Relation between Dartmouth College and its Graduate Schools." Dean Gray traced the early history of Dartmouth College and the history of the various schools, outlining the general curriculum at Dartmouth and pointing out the conditions under which men were admitted to the Thayer or Tuck Schools at the end of the junior year. The first year of work in the graduate school is counted toward the A.B. degree at Dartmouth College, the advanced graduate degree being given for the second year of work in the graduate school.

At two o'clock Dean Cloke opened the afternoon meeting and introduced Chester L. Dawes, Professor of Electrical Engineering at Harvard Engineering School, who read a paper on "The Graduate Work in New England Schools." The discussion was opened by Dean H. E. Clifford of the Harvard Engineering School, who emphasized particularly the desirability of devoting more time to liberal training before taking up the engineering course, making the regular engineering work more nearly graduate in character. Dean Marsden of the Thayer School amplified the statements of Dean Gray made at the morning session concerning the practice at Dartmouth. Professor Arthur E. Norton of the Harvard Engineering School brought out the desirability of more graduate work particularly in engineering mechanics. Professor H. P. Hammond discussed the desirability of part-time graduate work for men already in engineering practice, stating that this was now being done by Massachusetts Institute of Technology, University of Pittsburgh, Union, and Brooklyn Polytechnic Institute. At Brooklyn some two hundred and fifty men are now registered in such graduate work in evening courses, over two-thirds of them working for an engineering degree. Dean Slobin of the Graduate School of the University of New Hampshire emphasized the desirability of some graduate work being done in all institutions. Professor D. C. Jackson of Massachusetts Institute of Technology discussed various phases of the subject, particularly emphasizing various phases of graduate work on undergraduate instruction. Dean Bacon of

Tufts emphasized the point that research work could be carried on in the field without necessarily giving graduate work for masters' degrees. Discussion was closed by Professor Dawes.

Chairman Cloke appointed a nominating committee made up of Professors Farnham and Hitchcock and a committee on resolutions made up of Professors Jackson and Watson. An invitation to hold the fall meeting in 1931 at Brown University was extended. The meeting was then adjourned by the chairman.

Following dinner at the Hanover Inn, the group went to the Thayer School building for the evening session. Professor Farnham, for the Nominating Committee, presented the names of the retiring officers, Dean Paul Cloke of the University of Maine and James A. Hall, Professor of Mechanical Engineering at Brown University, as nominees for chairman and secretary for the coming year and these were elected. Professor Jackson, for the Resolutions Committee, presented the following resolutions:

Whereas, the New England Section of the Society for the Promotion of Engineering Education has just completed an agreeable and fruitful meeting at Dartmouth College at the invitation of the authorities of the College and of the Thayer School of Civil Engineering, therefore in expression of our appreciation of the courtesies accorded it is

Resolved:

1. That we extend to our host, Dartmouth College, represented by its Thayer School of Civil Engineering, our particular thanks for the numerous courtesies which we have enjoyed;
2. That we further thank the local committee, consisting of Dean Marsden, Professor Lockwood and Professor Garran, for the excellence of the arrangements made for our meetings and for the comfort and convenience of attending delegates;
3. That we salute and thank the local ladies' committee, Mrs. Lockwood, Mrs. Garran and Miss Fletcher, for the gracious entertainment of the ladies accompanying visiting delegates;
4. And that we are particularly grateful for the privilege, as a group, of examining the magnificent college buildings, the college campus and the glorious surroundings of this great college, the reputation of which is dear to all Americans.

A. E. Watson, *Brown University*,
D. C. Jackson, *Massachusetts Institute of Technology*, Chairman, Resolutions Committee.

Professor Hammond announced that two summer schools for engineering teachers would be held this coming summer, one in chemical engineering at Michigan, starting on June 24th, and one in mathematics at the University of Minnesota, starting on August 24th.

The secretary announced a registration of fifty-five men and twelve ladies.

Dean Cloke then introduced W. J. Sweetser, Professor of Mechanical Engineering at the University of Maine, who read an illustrated paper on "Flood Conditions in Vermont and New Hampshire."

The local arrangements were in charge of Dean R. R. Marsden and Professors Garran and Lockwood of the Thayer School, who took excellent care of the delegates. The ladies were entertained during the afternoon and evening by a committee of Dartmouth faculty wives.

In addition to the meetings themselves the entire membership had an exceptionally pleasant time sitting around the lobby and parlors of the Hanover Inn discussing topics of mutual interest.

JAMES A. HALL,
Secretary.

BOOK REVIEW

Principles of Engineering Economy. By EUGENE L. GRANT, Professor of Industrial Engineering, Montana State College. The Ronald Press Company, New York, N. Y. 387 pages, 12 charts, 32 tables. Price, $3.75.

The point of view from which this book is written is that the economic aspects of an engineering decision are governed by as definite a body of principles as are the physical aspects of design. While in no way overlooking the importance of the physical aspects, the author's treatment emphasizes many principles frequently overlooked.

The text is clear and ample cases are presented to illustrate the various problems presented. There is a noticeable lack of mathematical formulas, the author having used examples to clarify each principle set forth. In addition there are some hundred and thirty problems for student use. These problems cover an unusually wide range of type and show great thought in their preparation.

Three distinct parts make up the text; namely,

I. The Arithmetic of Engineering Economy.
II. Fact Finding in Economy Studies.
III. Background for Economy Studies.

Numerous chapters, clearly titled, make up each of these three parts. It would be difficult to list all the outstanding chapters without quoting the entire table of contents. Industrial engineers have long felt the need for just such a book,—both for text and reference use.

An engineer has been aptly defined as "a man who can do with one dollar what any fool can do with two." To live up to this definition, every engineer, in any branch of the profession, should be versed in the fundamentals of engineering economics. In writing this text, Professor Grant has filled a long-felt need.

J. W. H.

A MARKET ANALYSIS OF ELECTRICAL ENGINEERING GRADUATES *

By R. G. KLOEFFLER

Professor and Head, Department of Electrical Engineering, Kansas State Agricultural College

Foreword

The material for this paper was collected and prepared for a special report in "Sales Management" at the Harvard Graduate School of Business Administration. The original title of the report has been retained in this paper.

A market analysis is a study of the field of distribution for a specific product and includes such factors as (1) the total potential market, (2) the past market (3) the present market (4) the future market (5) the factors which influence the market and (6) competition.

The market analysis covered in this study differs from those usually made in the commercial world in the following ways:

1. Personal services are being considered instead of material things.
2. Production requires from four to six years instead of a period of one hour to six months.
3. Production is not controlled by present market conditions.
4. The value of personal service when first sold is at a minimum value and increases with time whereas the value of material things is usually at a maximum initially and decreases thereafter.

The object of this analysis of Electrical Engineering graduates is threefold.

1. To determine the distribution of Electrical graduates in different fields.
2. To determine the relation between supply and demand of Electrical Engineering graduates.
3. To obtain an estimate of future openings for Electrical Engineering graduates.

A market analysis for graduates in Electrical Engineering should begin with a consideration of the potential openings for the

* Presented at the Conference on Electrical Engineering at the annual meeting of the S. P. E. E., at Montreal, June 26–28, 1930.

graduates. The potential field may be classified in many ways, three of which are as follows.—(*a*) Types of work, (*b*) major fields in which work may be performed and (*c*) leading employers of Electrical Engineering graduates.

The various types of work may be listed as follows:

Classification I

1. Consulting Engineering.
2. Research
   (*a*) Pure science.
   (*b*) Development.
3. Design Engineering.
4. Application Engineering.
5. Operating, Service, and Construction.
6. Commercial Engineering
   (*a*) Sales.
   (*b*) Office and management.
7. Manufacturing.
8. Miscellaneous work
   (*a*) Teaching.
   (*b*) Sales (non-electrical).
   (*c*) Business.

The major fields in which work may be performed are:

Classification II

1. Electric Power Field
   (*a*) Manufacturing.
   (*b*) Public utilities.
2. Electrical Communication Field
   (*a*) Telegraph.
   (*b*) Telephone.
   (*c*) Radio (commercial messages).
3. Vacuum Tube Applications
   (*a*) Radio receivers.
   (*b*) Talking movies.
4. Illumination Engineering. (This is a minor field judged by the number of openings.)
5. Non-engineering Field.

The leading Employers of Electrical Engineering graduates are given in the following classification:

Classification III

1. Electrical Manufacturers
   (*a*) Power.

(b) Telephone.
(c) Radio.
(d) Illumination.

2. Communication Companies
   (a) Management.
   (b) Research and development.
   (c) Telephone operating.
   (d) Long distance.
   (e) Radio transmitting companies.
   (f) Telegraph.
3. Central Stations. (Electric power public utilities.)
4. Miscellaneous
   (a) Railroads.
   (b) United States government.
   (c) Educational institutions (teaching).
   (d) Business.
   (e) Etc.

The specific market analysis in this paper is being limited to graduates who complete their college training each year. This limitation is justifiable because the opportunities for the inexperienced graduate should reflect the opportunities open to earlier graduates and show the interaction of the natural economic forces of supply and demand.

With the above limitation given to this market analysis, Classification III becomes of the greatest importance since it represents the direct outlet (market) for the yearly graduates in electrical engineering. And fortunately this market (the employer) is one which is willing to give data regarding its needs for the past, present, and future. While there are many concerns which employ Electrical Engineering graduates, there are a few of them which hire the bulk of all graduates and this likewise tends to simplify the analysis and make for more accurate results.

The present analysis contemplates a period of ten years—from 1925 to 1935 inclusive, with special emphasis upon the year 1930. The data for this study have been secured through questionnaires which were mailed to about 100 employers coming under Classification III. The questionnaires asked for the following information:

1925 E.E. graduates employed during 1925 ——————
1929 E.E. graduates employed during 1929 ——————
1930 E.E. graduates employed during 1930 (estimated) ————
1935 E.E. graduates employed during 1935 (estimated) ————

The response to the questionnaire was highly satisfactory in the number of replies and the completeness of the replies.

It has been rather difficult to classify the information given by the questionnaires because some large companies with diversified products and activities come under two or more parts of Classification III, and yet the employment is made by a single department. Recent mergers in the electrical field have complicated the problem of classification still more. The classification which has been adopted for the purpose of this paper divides the field into five groups. The first four groups is given in Table I and the fifth in Table II. Table I contains almost all of the information provided by the questionnaires and covers the groups usually associated in the mind of the student with the field of Electrical Engineering.

TABLE I

Group	Number reporting	1925	1929	1930 (estimated)	1935 (estimated)
Electrical Manufacturers (Power equipment)	9	763	937	909	1038
Telephone—Telegraph—Radio (Commercial messages)—Manufacture, development, and operation	10	273	796	759	939
Applications of Vacuum Tube (Vacuum tube and radio—research, development, and manufacture)	4	15	129	167	283
Central Stations (Public utility)	35	225	274	323	416
Total	58	1276	2136	2158	2676

The data given in Table I have been plotted in the curves of Fig. 1. In studying these curves one should remember first that this distribution applies to the college graduates at the time they leave college and that it is not the distribution of Electrical Engineering graduates at a later period and second that the part of the curve covering the future represents the opinions of men in the personnel departments of industry. The electrical manufacturers of power equipment employ the largest number of E.E. graduates with the general communication group coming next. This general communication group covers the Western Union, Postal Telegraph, the Bell System, The International Telephone and Telegraph Company, The Radio Corporation of America and a number of independent telephone manufacturing and operating companies. This group has had a rapid growth in the past five years which has been reflected in the openings for college graduates in Elec-

trical Engineering. The group styled Vacuum Tube Applications covers general vacuum tube and radio applications outside of the general communication group. It is a group which had its origin about five years ago. It is interesting to note that the slope of the curves for all four groups for the next five years is very nearly the same.

The Electrical Manufacturing Group and the Central Station Group deal in power equipment and production and hence have certain things in common and might be classed together. Likewise the General Communication Group and the Vacuum Tube Application Group have certain elements that are alike and might be classed together. If such unions of these four groups be made the power group constitutes approximately 58 per cent. and the communication group 42 per cent. of the number represented on Fig. 1.

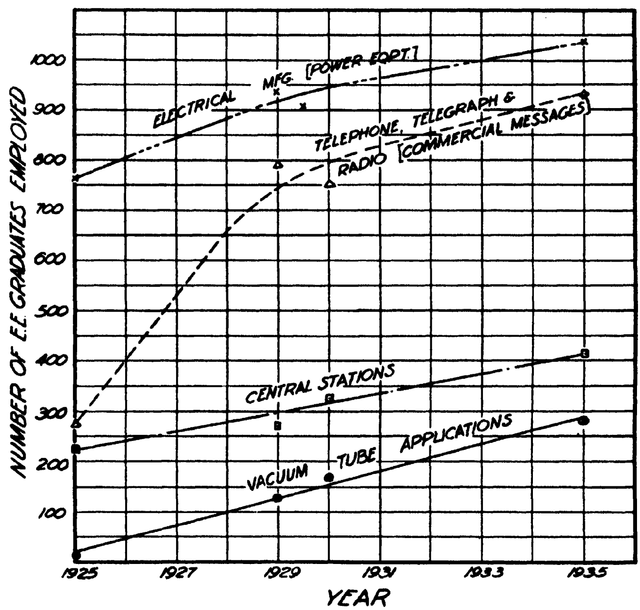

FIG. 1

The questionnaire did not and could not cover a large group of miscellaneous outlets for the Electrical Engineering graduates. An attempt to cover these outlets has been made in Table II. Those figures covered by an asterisk were obtained by questionnaire, the others are intelligent guesses of the speaker which were

checked and modified by intelligent guesses from others. The intelligent guesses have been substantiated in part by replies to questionnaires from railroads and by many contacts in placement work.

TABLE II

	1925	1929	1930	1935
Railroads	20	30	30	40
Civil Service	*3	*20	25	35
Army and Navy	*2	* 0	0	0
Illumination	10	15	15	20
Aviation	0	10	10	10
Auto industry	25	30	20	30
Teaching	125	150	150	150
Business (Misc.)	150	250	250	300
Agriculture	15	15	15	15
Remain in college (for advance work)	100	150	150	200
Total	450	670	665	800

It should be of interest to know the relation between the supply and demand of Electrical Engineering graduates. An attempt to show this relation has been made in the estimated figures of Table III. Since the questionnaire was not sent to numerous small electrical manufacturers the actual data collected for this group have been increased by 5 per cent. in Table III. Similarly only the larger central stations of the public utility group were covered and all of these did not answer. Hence the data for this group have been increased by 25 per cent. The totals for Table II and III

TABLE III

Elect. Mfg. (Power equip.)	+ 5%	800	984	955	1090
Telephone, Telegraph, Radio	0	273	796	759	939
Vacuum Tube Applications	0	15	129	167	283
Central Stations (Public utility)	+25%	283	342	403	520
Miscellaneous Group, Table II		450	670	665	800
Total		1821	2921	2949	3632

have been plotted in Fig. 2. A third curve in Fig. 2 shows the number of Electrical Engineering graduates for each year since 1921 as given by the United States Office of Education and by surveys of some of the largest electrical manufacturers.

The curve covering Table III reaches close to the curve for the number of graduates for the year 1929. And it is a well known

fact that the demand for electrical Engineering graduates in 1929 exceeded the supply. Thus it would seem that the assumptions of Table II (made before Fig. 2 was considered) must be too con-

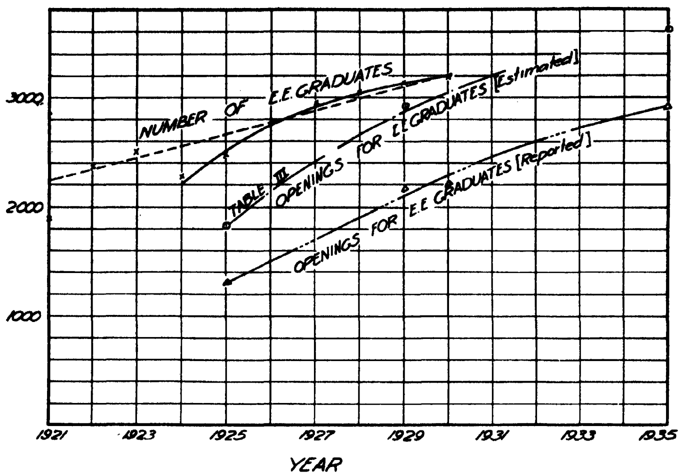

FIG. 2

servative. The fact that the difference between the opening and the number of graduates in 1925 seem to be greater than in 1929 may be explained by a lack of adequate personnel records at the earlier date. The dotted line for the number of Electrical Engineering graduates indicates the trend over the past nine year period. The curves showing the relation between supply of and demand for Electrical Engineering graduates are nearly parallel and thus indicate a healthy and desirable condition—sufficient openings for the capable college graduate and enough men to fill the vacancies in industry.

The distribution of the Electrical Engineering graduates has been considered to be that static condition which exists during the first year after graduation. We may be interested in the dynamic condition or distribution a few years after graduation. This future distribution may be estimated by a consideration of probable future shifts. Thus the electrical manufacturers give statements from time to time of the percentage of college graduates who remain with them permanently. The percentage is usually 60 to 65. A large part of those who leave go to the central stations and the rest into miscellaneous types of work. A small part of those who go into the general communication field join the central sta-

tion or miscellaneous group. After these shifts have taken place one should find approximately 25 per cent. of the college graduates in each of the four main groups, viz: the electrical manufacturer, communications, central station, and miscellaneous.

In conclusion and by way of digression from the subject of this paper, it is desired to point out that the information gathered in preparing this discussion shows that a large per cent. of Electrical Engineering graduates go into a type of work where vacuum tubes and the theory of electronics play a large part. I am seriously wondering whether all of our curricula in Electrical Engineering provide one of more courses which cover the fundamentals of electronics. The art is relatively new and has had enormous expansion in recent years. I plead guilty as one representing a college where until recently, it was possible for a man to be graduated without a required course covering the theory of electronics. It is easy for us to let our curricula become dusty but it is my hope that we do not let such dust obscure the need of revisions to cover this field.

THE DEVELOPMENT OF BRIDGE CONSTRUCTION *

By PHILIP G. LAURSON

Associate Professor of Engineering Mechanics, Yale University

Bridge construction is an ancient art but a modern science. As an art it developed slowly and in a limited way over a long period of historical time. Its development as a science has been brief in point of time but almost incredible in extent.

As an art alone it achieved many beautiful structures of a few types. As a science it achieved wonderful structures—strong and efficient but generally plain or even ugly. There is reason to hope that an era has begun in which bridge construction will unite the perfection of beauty attained in the fullest development of the art with the perfection of strength and utility which can be attained by the application of the perfect science. Such a union of art and science can achieve bridges which satisfy both the demands of utility and the cravings of esthetics.

It is not primarily of esthetics that I am to speak. My aim is to trace the development of bridge construction from the primitive inventions to the present high development—through the period of the art into the period of the science of structures and down to the present day.

Before we begin our journey through thirty and more centuries of time I propose to point out five great influences without which bridge construction would not have advanced to its present state. These influences were either inventions or discoveries (it matters not which) or the direct results of inventions and discoveries.

Primitive men did not need to invent simple slab and beam bridges. Fallen trees and natural stone slabs accidently formed small bridges which were improved and copied. In this manner stone bridges a few feet in span, and wooden bridges somewhat longer were made without invention and with little thought. Then some one, at some time (we care not who nor when) invented the arch and forthwith stone bridges with spans greater than the length of a single stone became a reality. This is the first of the great inventions.

Probably many centuries later, when men used wood-working tools, it was found that frames could be built of pieces of wood

* A lecture delivered before the Civil Engineering Session of the Summer School for Engineering Teachers, Yale University, July 9, 1930.

and that such frames could be made to span openings longer than the length of any stick in the frame. This (probably not the invention of any individual) was the second great invention. Its effect was important after the close of the "dark ages."

The third great invention had to do with materials instead of structural types. Processes for producing iron and steel in large quantities and at low cost revolutionized the art of bridge building. Gradually, between 1500 and 1800, cast iron was developed and cheapened. The names of Dudley and Darby are important in this development in connection with the use of coal for smelting and steam for operating the blast furnaces. Then, late in the 18th Century, Henry Cort was largely responsible for devising economical methods of puddling and rolling wrought iron and this metal also soon became available in quantities. Before 1860 Henry Bessemer invented the Bessemer process for steel production and shortly thereafter Sir William Siemens and P. and E. Martin developed the open hearth process for steel. Before Bessemer's invention steel had been a comparatively rare metal useful for blades and tools; after these inventions new materials were available for bridges.

The fourth great influence was an indirect one, but one which played an important part in the development of bridge construction. The rapid spread of railroads required the construction of bridges in incredibly large numbers. Furthermore, railroads were commercial ventures and were therefore expected to pay dividends. The bridges which carried them over the rivers had to be built at the lowest cost and in the least possible time. And in addition, the character of loading required strong and rigid bridges. This commercial development was an unprecedented stimulus to the construction of bridges.

The fifth great influence was the perfecting of the principles of stress analysis and design, making possible the scientific design of beams and trusses. While this did not come all at once, only a few decades elapsed from the time when bridges were designed purely by empirical methods to the time when almost exact calculations could be made for trusses and beams.

It will be helpful to keep these five great influences in mind as we follow the lines of progress in bridge building.

It seems that an historian must divide time into periods. For our purpose the time which has elapsed during the development of bridge building will be broken up into four periods. The first period begins as far back as you care to have it and extends to 1775; probably about thirty centuries will include most of what is historically known of the development up to this time. The second period extends for 1775 to 1850, three-quarters of a century.

The third period is the last half of the nineteenth century and the fourth period includes the twentieth century to the present time. I shall not undertake to look into the future.

Bridges before 1775.—Of all ancient peoples only the Romans participated to any great extent in the development of bridge construction. They were great colonizers, pushing their military roads into all parts of their known world. This required bridges. But above all they had a peculiar genius for building bridges and aqueducts. Many of these still stand intact after eighteen centuries and more. We must realize that those now standing are but a small

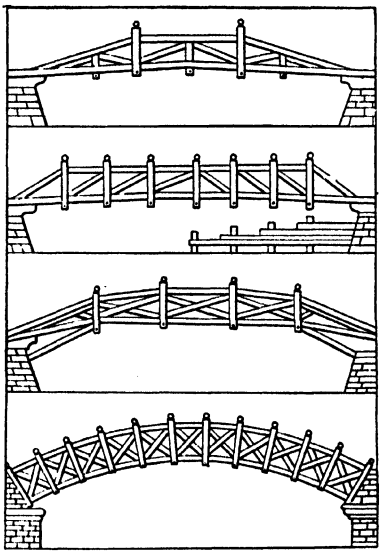

FIG. 1. Trusses Used by Palladio.

part of those built. Those still enduring are monumental structures. There were innumerable smaller utilitarian structures of wood and stone. Timber cleared from the rights-of-way of the straight Roman roads was more than ample for most of the bridges. Pile trestles were very common structures. Fire and decay have obliterated these and few were thought worthy of a place in written history. The Pons Sublicius (which simply means "the pile bridge") over the Tiber at Rome was built more than six centuries before Christ and endured for at least three centuries, carefully repaired by the chief priests. Julius Caesar, during his invasion of Germany, bridged the Rhine with a very creditable pile

trestle. It is far more important that he was a writer and gave us a careful description of this. The 1800-foot trestle was built in ten days with enemy forces threatening the builders; which is good evidence that such construction was common and that the workers were skilled in planning and executing this type of bridge.

Skipping centuries, let us next consider the work of an Italian architect, Andrea Palladio, born in 1518, who made drawings of wooden frames which he used in bridges and roofs. They differ little from some modern trusses. Here was one of the great inventions of bridge construction, making possible the construction of long spans from short pieces, and without the necessity of the substantial horizontal abutments required by arches.

FIG. 2. Ponte Molle, Rome, 109 B.C., restored (reproduced from Wilbur J. Watson's "Bridge Architecture," by courtesy of Wm. Helburn, Inc., publishers).

Two centuries later, near the close of this period, two Swiss carpenters, Ulric and Jean Grubenmann, became famous as builders of wooden bridges. Their masterpiece was a wooden bridge with a clear span of 390 feet—the longest wooden span ever built.

But the most important development during this period was that of the masonry arch. It began, probably more than 3000 years before Christ. I do not think it was suggested by the natural stone arches, as do so many writers. This invention was well within the ability of men of early civilizations. We know that by 578 B.C. the great main sewer of old Rome was built, with a diameter of eleven feet—a semi-circular arch with radial joints. This implies rather advanced knowledge and experience in this structural form. By 100 B.C. the Ponte Molle was built across the Tiber. This is a

splendid piece of engineering which has been somewhat restored during its life of twenty centuries. The necessity for maintaining high elevations where aqueducts crossed valleys resulted in magnificent structures. The Pont du Gard at Nîmes, in France, was built within a few years of the beginning of the Christian era. One cannot look at this aqueduct without feeling that the art of building bridges of stone was very close to its culmination while Christ was a young man in another Roman province. Within the first century the aqueduct at Segovia, in central Spain, was finished, and it is

FIG. 3. Detail of Roman Aqueduct, Segovia, Spain, 98 A.D. (reproduced from Wilbur J. Watson's "Bridge Architecture," by courtesy of William Helburn, Inc., publishers).

still bringing cold water from the Sierra Fuenfria. It is nearly half a mile long and over 100 feet high. The stones are rough-hewn granite, laid up without mortar.

It hurts a Pontist (as W. Shaw Sparrow calls a devotee of bridges) to pass lightly over the lovely and picturesque bridges of the dark ages—bridges built with much feeling and skill, but without much science. Many of these were constructed in the spirit of public service to travellers and pilgrims. Some were commercial ventures and some were built with military needs in mind. One of the oldest existing medieval bridges is thought to have been built during the reign of Charlemagne, in the eighth century.

About 1177 there came into being a religious order in France—"The Brothers of the Bridge." Its purpose was to aid travellers and pilgrims by building bridges. During the three centuries of its existence many fine bridges were built by its members. The best known of these is the bridge over the Rhone at Avignon, a few miles from the Pont du Gard. It is often called the bridge of St. Benezet after its builder, who died before its completion and is buried in the chapel over one of the piers. There were probably twenty-one arches, the longest about 110 feet, of which only four remain. Because of its interesting history and tradition, writers have described this bridge at great length, although there are other bridges equally remarkable and equally old.

FIG. 4. Medieval Bridge, XIVth Century, Montauban, France (reproduced from Wilbur J. Watson's "Bridge Architecture," by courtesy of Wm. Helburn, Inc., publishers).

About the same time Peter Colechurch, a priest, made plans for a great bridge over the Thames at London. After 33 years of labor this was finished in 1209. The bridge was endowed by the people of England with money and lands and its history and tradition has filled books. After a life of nearly six and a quarter centuries it was replaced by the new London bridge, finished by Sir John Rennie in 1831. Though substantial and well founded on elm piles, the old London bridge was, in many respects, a poor piece of engineering. It has been called a "pierced dam" for the clear openings totalled only about one-third of the length.

Of the scores of important masonry bridges built during this period I can mention only two which are typical. The bridge crossing the Tarn at Montauban is an example of a splendid brick bridge. It was finished in 1335 after many years of work and a

century and more of talking. The arches are about 70 feet in span. The bricks used were several times as large as present-day bricks. In five years the bridge will have its 600th birthday, having safely survived only last spring another very serious flood of the temperamental Tarn River.

Gradually a new culture developed in Europe called the Renaissance. Architecture and bridge building were influenced as were all arts and industries. Contrast the sixteenth-century Ponte della Trinita at Florence with the bridges of Rome and the middle ages. The semi-circular arches have given place to delicate elliptical arches with small rise. Mouldings and ornament have been added. The whole effect is the resultant of perfect comprehension of esthetic laws and a high degree of skill in construction.

And so we come to the time of the American war for independence. The achievements of man in bridge construction up to this time have been small beam bridges of stone and timber, bold Roman arches, giving way to picturesque medieval bridges, and these in turn evolving into the esthetic refinement of the later Renaissance. Besides these, a few trusses have been constructed by builders without any knowledge of stresses or strength of materials. The materials of bridge building have been, up to this time, only wood, brick and stone.

Bridges from 1775 to 1850.—Let us see what the next three-quarters of a century accomplished. Newcomen and Watt had developed steam engines into fairly efficient and reliable sources of power. While this development went on Abraham Darby—father, son and grandson—owners of iron works at Coalbrookdale, England, had succeeded in using coal instead of charcoal for smelting iron and had applied the new "fire engine" for blowing, instead of the "water engines" commonly used. When the third Abraham Darby took over the iron works the traffic in coal, iron, brick and pottery had grown to such an extent that the ferry over the Severn was entirely inadequate. It was natural enough for Darby to decide to build a bridge. But we must regard it as somewhat remarkable that he decided to cast it in his foundry. This had never been done before! It was not a bridge of ten or twenty feet, but an arch bridge of 100 feet that Abraham Darby cast and erected where since the little town of Ironbridge has grown. It was not an imitation of a stone arch, nor a replica in iron of any wooden bridge. Here were entirely new forms for which only this new material could be used. I think you will agree that in 1779, when Darby had finished the first iron bridge in the world, a new period in bridge construction had begun. The bridge is still in service today after a century and a half.

Scores of cast-iron bridges were built in the hundred years following Darby's successful venture. Many of these were imitations of stone voussoir arches, such as the Sunderland Bridge over the Wear River in England. The design of this carried out the ideas of Thomas Paine—author and social reformer—and the arch was built partly from iron previously used by Paine in a model for a 400-foot bridge proposed by him for Philadelphia. Thomas Telford and John Rennie both built cast-iron bridges, Telford seriously proposing one with a span of 600 feet over the Thames at London.

FIG. 5. First Iron Bridge, 1779, Cast-iron Arch at Coalbrookdale.

The introduction of a new material is a significant step in bridge construction. We have seen how cast iron became available. In 1783, Henry Cort, a dealer in iron bolts and fittings for wooden ship building, invented grooved rolls and applied his invention to the rolling of wrought iron. The following year, 1784, he patented the method of refining known as puddling, which is still used in the making of wrought iron. These two inventions increased the production of wrought iron and greatly lowered its cost, making another material available for construction uses when the need for it should arise.

While cast-iron bridges were being built in Europe a remarkable development of wooden bridge construction was taking place in the United States. Highways were being extended at a remarkable rate and the growth of industries demanded more and better bridges. The logical material was wood, available in unlimited quantities and of the best quality.

The first long span wooden bridge in America was built in 1792 over the Connecticut River at Bellows Falls. It was designed by Col. Enoch Hale and had two spans of 175 feet each. It was of a type which (with many variations) was widely used in America during the period we are considering. This consisted of a curved arch rib with a trussed frame attached to it,—a highly indeterminate type. In fact, only by a thorough understanding of the principles of structures can indeterminateness be avoided and such knowledge did not exist at this time.

The same year (1792) Timothy Palmer built a bridge at Newburyport, Mass., with a span of 160 feet. From 1801 to 1805 he was building the "Permanent Bridge" in Philadelphia, with a span of 195 feet. Theodore Burr was another builder of long span wooden bridges. His best-known bridges were those at Waterford, Trenton, and Schenectady.

Some of the most remarkable American wooden bridges were built by Louis Wernwag. The "Colossus" Bridge over the Schuylkill River at Fairmount, his masterpiece, was finished in 1812 and had a clear span of 340 feet.

In 1820 a New Haven architect, Ithiel Town, invented and patented a new type of bridge—the Town Truss. His first bridge was built about two miles north of the center of New Haven, over the Mill River. Town's truss was strong and rigid, it exerted no horizontal thrusts on the abutments, and it could be manufactured out of sawn planks—greatly cheapening its construction. This was the first true truss in modern bridge construction and it greatly influenced later bridge building, a fact acknowledged both in Europe and in America.

In 1801 James Finley, of Fayette County, Pennsylvania, added another type of bridge to the existing modern bridges. This was the suspension bridge. It is true that there had been small suspension foot-walks built in the seventeen-hundreds, in which the floor followed the flexible curve of the chains. Finley, however, made the suspension bridge into a real bridge with level floor capable of supporting concentrated loads without undue deflection. An early drawing reveals all the elements of the modern suspension bridge. It shows at one end the roadway suspended from the backstays and at the other end the straight backstays and separately supported roadway. Finley patented this type in 1808. Thomas Pope carefully described it in his treatise on bridge architecture published in 1811.

The oldest American suspension bridge is the one at Newburyport, Mass., which was built in 1810 from Finley's design. The span is 244 feet, center to center of towers. In 1816 wire was first used in a small suspension bridge built for pedestrians by White

and Hazard, manufacturers of wire. The wire was $3/8$-inch in diameter. The bridge was 408 feet long and a toll of one cent per person was charged.

FIG. 6. Old Chain Bridge, Newburyport, Mass., 1810. (Reproduced from Wilbur J. Watson's "Bridge Architecture," by courtesy of William Helburn, Inc., publishers.)

Suspension bridges developed with great rapidity. In 1819 Thomas Telford began the construction of the Menai Straits Bridge.

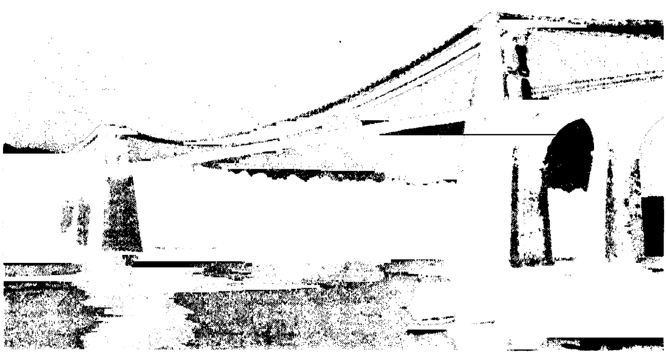

FIG. 7. Menai Bridge, Wales, Thomas Telford, 1820–1826.

The span is 580 feet and there are four chains of flat, wrought iron bars, each 10 feet long, united by short links and 3-inch pins. The bridge is still in use. Telford built several other suspension bridges.

The suspension type of bridge is an excellent one for long spans and can be built very cheaply if the loads are moderate. By 1850 more than thirty suspension bridges had been built. In 1848 the bridge at Wheeling, West Virginia, with a span of 1,010 feet was built. Needless to say, this span far exceeded the span of any other type of bridge at that time. There were also about this time a good many failures which cannot be recounted here.

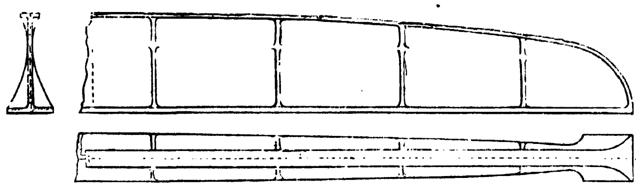

FIG. 8. Early Cast-iron Girder (from Encyclopedia Britannica, 1878).

The development of bridge construction might have run along at a slow and steady rate had it not been for the railroads. Since 1825 the demands of railroads have resulted in new types of bridges; larger, stronger, and more economical. Unfortunately many of these are needlessly ugly.

Stone and brick arches naturally met these needs excepting those of cheapness and speed of construction. Cast iron was immediately used, but before very long it was discovered that its brittleness made it unsatisfactory for railroad bridges.

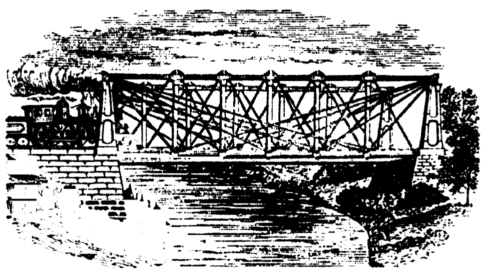

FIG. 9. Early Bollman Truss (from Mahan's "Civil Engineering").

Wooden trestles served admirably for some of the smaller bridges but the engineers who were called upon to build the bridges were driven to types that were new. The first iron railroad bridge was built on the Stockton and Darlington line in 1823 by George Stephenson. It was a very small trestle with lenticular trusses, without diagonals.

With an instinct for truss forms and by the aid of experiments, the railroad engineers invented more satisfactory types. In the United States, Wendell Bollman built bridges with the truss known by his name. These came into use about 1840 on the Baltimore and Ohio Railroad.

In 1840 Squire Whipple built a bowstring truss bridge with cast-iron top chords and wrought iron tension members, and in 1841 a patent was granted to him. This combination of cast and wrought iron was destined to play a large role in early truss bridges.

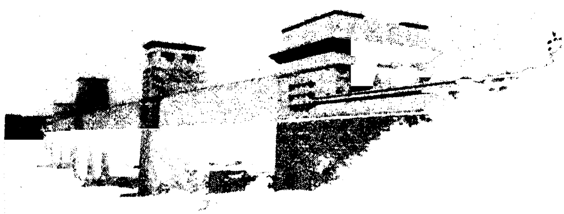

FIG. 10. Britannia Tubular Bridge, 1850 (reproduced from Wilbur J. Watson's "Bridge Architecture," by courtesy of William Helburn, Inc., publishers).

Robert Stephenson, in the 1840's, faced the necessity of a railroad bridge over the Menai Straits with the then enormous span of more than 400 feet He first turned to the cast-iron arch for a solution of his problem, but the Admiralty did not allow the encroachment on the headroom of the channel. Stephenson therefore turned boldly to a new type—the wrought-iron tubular bridge. Today it is almost impossible to appreciate the daring of this conception. Stephenson retained Fairbairn and Hodgkinson to carry out extensive experiments. They began with circular tubes and evolved the rectangular type with cellular top and bottom. The final experiments were on a model 75 feet between supports. Fairbairn was interested in iron ship building, and was familiar with riveted iron work. The tubes were built and successfully lifted into place, an achievement which, in one case, almost ended in disaster. By 1850 three tubular bridges were in use; the most important being the Britannia Bridge over the Menai Straits, having two spans of 460 feet each.

Not the least important developments of this period were the advances made in the theory of beams and trusses. The beam theory had been satisfactorily worked out by Navier about 1820. In 1847 Squire Whipple, in the United States, published a "Treatise on Bridge Building." This is now conceded to have been the first work correctly treating the analysis of stresses in trusses. Neither the theory of beams nor the theory of trusses were widely applied until after 1850.

The Period from 1850 to 1900.—And so we come to the third period of the development of bridge construction, from 1850 to 1900. During the previous 75 years many new types had been evolved and many successful bridges had been built, but mostly without scientific analysis.

During the fifty years of this half century the natural "survival of the fittest" narrowed the number of types to the few best adapted to the needs. Tubular bridges and cast-iron arches were built in this period, but became obsolete before it closed. The highly indeterminate types of trusses largely gave way to the simpler determinate types—even the continuous trusses becoming temporarily obsolete.

The period opens with but one small book correctly treating the stress analysis of trusses and closes with the subject well understood by the average civil engineer and taught in hundreds of schools. Other treatises followed close after Whipples', one by Haupt, independently written, appearing in 1851. The period opens with wrought iron as the principal material for bridges and closes with steel entirely supplanting it and alloy steels available.

Many stone arches were built in this period, but concrete became a rival of stone and reinforced concrete was developed, adding another material to those available for bridge construction.

Of the hundreds of important bridges only a few can be mentioned and these are not necessarily the greatest. At the beginning of this period plans were under way for the construction of the Newark Dyke Bridge to carry the Great Northern Railway over a branch of the Trent River in England. The designs were made by Charles Wild and the main spans were Warren trusses 240 feet in the clear. This was scientifically designed with cast-iron tubular compression members and wrought-iron tension members. Joseph Cubitt described this in the Proceedings of the Institution of Civil Engineers, and stated: "The parts are so proportioned, that when loaded with a weight equal to one ton per foot run, which considerably exceeds the weight of a train of the heaviest locomotive engines in use on the Great Northern, or on any other narrow gage *

* "Narrow gage" at this time in England meant 4 feet, 8½ inches. The "wide gage" was 7 feet.

line, no tensile or compressive strain on any part exceeds 10 tons per square inch of section.'' This bridge was finished in 1853, the

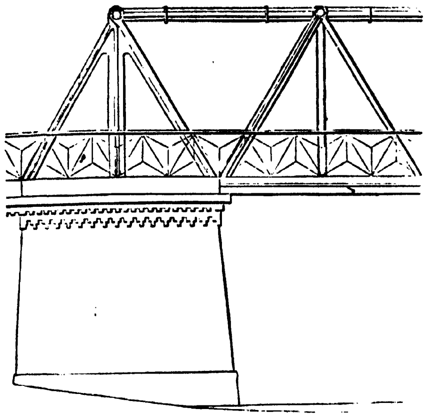

FIG. 11. Newark Dyke Bridge (from Encyclopedia Britannica).

first example of a type of truss that is still commonly used—the Warren truss, named after Captain Warren, an Englishman.

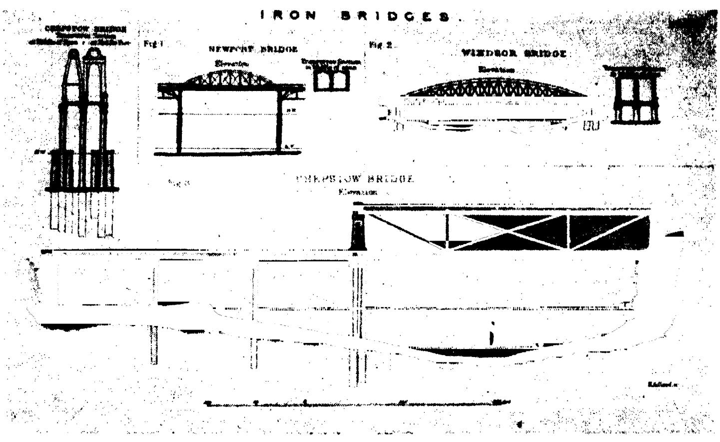

FIG. 12. Early Truss Bridges (about 1855, I. K. Brunel, Engineer (from "Life of Brunel")).

In America, Whipple adopted the type which bears his name. Diagonals crossed two panels, making correct stress computation

difficult. In 1852 one of these was built near Troy, New York. Many more were built before it became absolute.

Fink trusses followed soon after the Bollman trusses, the first large one being built in 1852 at Harpers Ferry. The span was 124 feet.

In England at this time, I. K. Brunel was groping for suitable types for long-span railroad bridges. He was a man of considerable originality though at times his judgment was not the best. By 1850 the Windsor Bridge had been finished with bowstring trusses, and in 1852 he finished the Chepstow Bridge, a through Pratt truss of 300 feet span. Its proportions and details are strange indeed. There are only three panels of 100 feet each, and there is a single tubular top chord serving for two trusses. This latter peculiarity he repeated in the Saltash Bridge, where the single top chord is a tube 16 feet, 9 inches broad and 12 feet, 3 inches high. This bridge

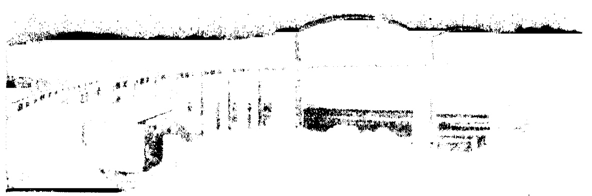

FIG. 13. Royal Albert Bridge, Saltash, I. K. Brunel, Engineer (from "Life of Brunel").

(opened by Prince Albert in 1859) is still in service. Probably Brunel thought that this arrangement was best and expected it to be generally used in the future, just as Stephenson believed that the tubular type of bridge was the last word in long span bridges.

By the beginning of this period the suspension bridge had been well developed. In 1854 John A. Roebling, a builder of experience, finished the first and only important railway suspension bridge at Niagara Falls. It was a double deck structure with a span of 821 feet between centers of towers—much the longest railway span at the time. There were four cables, each 10 inches in diameter. It served (with extensive repairs) until replaced by a steel arch in 1896.

The development of railroad truss bridges is too complex to treat in detail in a short talk. After 1860 bridge companies were formed, generally with the bridge engineers from railroads as their chief engineers. A pretty good picture of the status of truss bridge development can be had by looking at the advertisements appearing in old magazines. In one issue of the Railroad Gazette in 1875 seventeen different companies advertise nearly as many types of bridges. Of these only two types would be favorably considered today—the Pratt and the Warren. The Patapsco Bridge Company

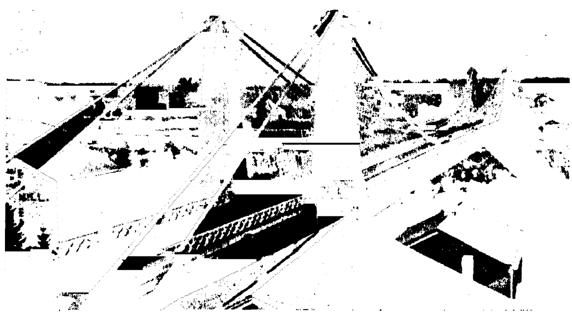

FIG. 14. Roebling's Niagara River Railway Suspension Bridge.

(Wendell Bollman, Proprietor) displays the Bollman truss. The Louisville Bridge and Iron Company (Albert Fink, President) shows the Fink truss. A. J. Post is Engineer of the Watson Manufacturing Company, "Builders of Post's Patent Diagonal Truss Bridges of iron, wood, or wood and iron combined, for railroads, highways, roofs, turn-tables and general machine work." The Whipple truss is advertised by the American Bridge Company (not the present company of that name). Charles H. Parker is one of the proprietors and also Engineer of the National Bridge and Iron Works, displaying the Parker truss—the only one with curved top chord. J. H. Linville is president of the Keystone Bridge Company, which displays a swing bridge (Linville was the first to use wide, forged eyebars, 1861). The Baltimore Bridge Company, C. Shailer Smith, President and Chief Engineer, shows a subdivided Warren truss. Willard Pope is President and Engineer of the Detroit Bridge and Iron Works, displaying the Pratt truss.

Many wooden Howe Trusses were used for railroad bridges in this period. In Europe the lattice truss of wrought iron was very popular over a long period. A famous example is the lattice bridge

over the Rhine at Cologne, Germany, built in 1859, with 322-foot spans.

In 1876 C. Shailer Smith built the first important railway cantilever bridge—the Kentucky River "high" bridge, with three 375-foot spans. The advantage in erection of this type made it widely used from this time on.

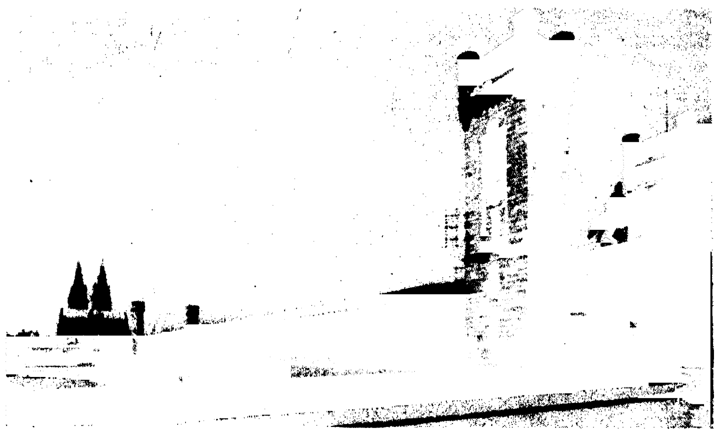

FIG. 15. Lattice Railroad Bridge, Cologne, 1859 (from Whitney's "Bridges').

During this half century there occurred two or three of those outstanding achievements that mark advances far beyond normal progress. James B. Eads built his great arch bridge over the Mississippi River at St. Louis between the years 1869 and 1874. The center span is 520 feet. The ribs are tubes of chrome steel—the first extensive use of steel in bridge building. It was erected by cantilevering from each pier, probably suggesting the advantages of cantilever bridges. Between the years 1869 and 1883 the Brooklyn suspension bridge was designed by John A. Roebling and built by his son, Washington Roebling. The span is 1595 feet, center to center of towers. Between the years 1882 and 1890 the Firth of Forth cantilever was built; Sir John Fowler and Sir Benjamin Baker, designers. No description of this bridge is needed. The main members are tubular—a boiler maker's job rather than a bridge fabrication job in the modern sense. The material was open-hearth steel. For 27 years its two spans of 1710 feet were the longest. The boldness of these three bridges cannot be realized at the present time. Each was of a magnitude far beyond anything before it. It must be granted that metal bridge construction was already in an advanced state to make such structures possible.

The closing years of the nineteenth century saw steel completely replace wrought iron and concrete become a rival of stone for all except the most expensive arch spans. Reinforced concrete was added to the materials available for bridge builders. A few, simple, rigid, well-established truss forms replaced the innumerable combinations devised at the beginning of the half century.

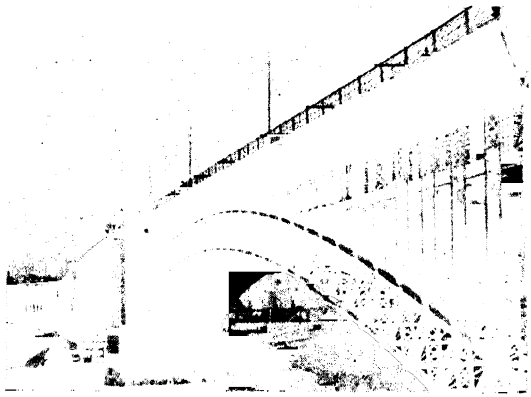

FIG. 16. Ead's Bridge, St. Louis, 1868–1874 (from Whitney's "Bridges").

Since 1900.—The development of bridge construction resembles the growth of a mighty tree. The roots go deeper and deeper and the branches spread wider and wider, and in each succeeding year increase in number. It becomes increasingly difficult to picture with any detail the later developments of bridge construction. Very sketchily have these developments been outlined up to the close of the nineteenth century.

Only a glance is possible at the developments of the twentieth century. New conditions exist. Financial resources are available for projects on a larger scale than ever before. The Firth of Forth bridge cost $16,000,000 and required eight years of time. The new Delaware River bridge cost something more than twice that amount of money, while the Hudson River Bridge may cost five times that amount.

But other resources are also available that were lacking in earlier times. Eminent engineers with long experience are on hand to design the bridges. Large bridge companies are ready to contract to carry out the plans. Under the chief engineers is a staff of highly competent assistant engineers, and a company of draftsmen well-trained in the work of preparing the actual plans. Ma-

terials of higher quality are available in unlimited amounts. Tests and researches are carried out before the work begins and as it progresses. The results are bridges which are bigger and safer than any that were built in earlier times.

A few of the advances that characterize the twentieth century bridge construction will be mentioned. Greater refinement in calculation, often including the calculating of secondary stresses due to rigid joints. These in many instances, are checked by field measurements with strain gages, and in some instances initial deformations have been given to members during erection to reduce secondary stresses under load. More exact methods are now used in the design of suspension bridges, eliminating previous false assumptions and approximations. Continuous and other indeterminate types are accurately designed, and in some types scientific *mechanical* analysis is used.

In actual construction greater rigidity and more substantial details are the order of the day. At the present time a large part of nearly every great structure is alloy steel or heat treated carbon steel. This permits increased unit stresses without sacrifice of safety. Without this economy of weight our largest spans would not be feasible.

There are still many open questions upon which engineers are divided. And, after all, as Professor Swain used to say, the big question for the bridge engineer to settle is not "how to build a bridge," but "whether to build a bridge." The success of modern tunnels has made this question even more acute.

The twentieth century has produced the greatest bridges of every type excepting those which have become obsolete, such as the tubular girders and wooden arches. There is time for the mention of only a few. The Frederic August Bridge at Plauen, Saxony, with a span of 295 feet is the longest stone arch. It represents a gain of 44 feet in five centuries.

Among the many long reinforced concrete arches is one at Saint Pierre du Vauvray, France, with a span of 430 feet. At Brest there is nearing completion a reinforced concrete arch of 612 feet.

The largest cantilever bridge is the Quebec Bridge with its span of 1800 feet. This span is about 5 per cent. greater than the span of the Firth of Forth Bridge, which was finished 27 years earlier.

Many large continuous truss bridges have been built since 1915. The largest is the Sciotoville Bridge, with a truss 1550 feet long, resting on three supports. This was completed in 1916. In the same year the longest simple truss was finished. This is in the Metropolis bridge over the Ohio river, with a span of 720 feet.

While the largest and heaviest arch in service today is that of

the Hell Gate Bridge, there are two nearing completion with much longer spans. These are the Kill von Kull bridge, with a span of

FIG. 17. Highway Bridge at Saint-Pierre-du-Vauvray, France, 430 foot span (from Whitney's "Bridges").

1652 feet center to center of pins, and the Sidney, Australia, arch, with a corresponding span of 1650 feet. There is also under con-

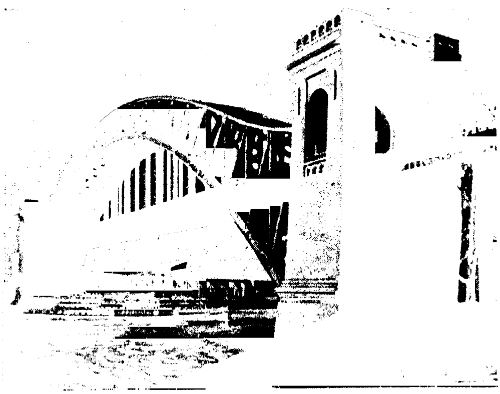

FIG. 18. Hellgate Bridge, 1916 (reproduced from Wilbur J. Watson's "Bridge Architecture," by courtesy of William Helburn, Inc., publishers).

struction the Hudson River suspension bridge, the span of which (3500 feet) nearly doubles that of the largest existing suspension bridge.

The Firth of Forth bridge (begun fifty years ago), the still older Brooklyn bridge and the Eads Bridge are evidence enough that the twentieth century holds no monopoly on creditable achievement. Great progress has been made but the pioneers who designed

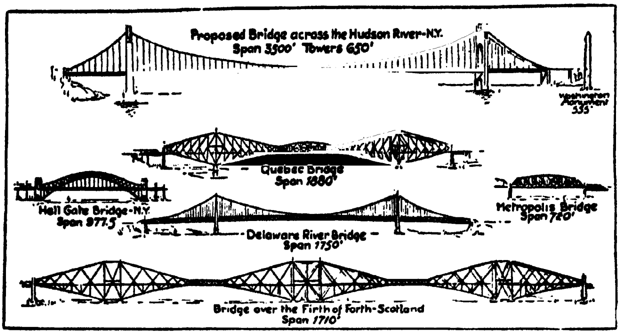

FIG. 19. Diagrammatic View of Long-Span Bridges, drawn to the same scale.

and built the great bridges of earlier times were surely great engineers. Let this generation give them the credit and praise which, it is to be hoped, the generations to come will be ready to award to the bridge builders of today.

THE RELATIVE VALUE OF THE TEACHING OF MACHINE DESIGN WITH AND WITHOUT THE MAKING OF DRAWINGS

By W. V. DUNKIN *

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A few years ago the design of machinery was, for the most part, of an empirical nature. Types of structures and machines were simple. The demands for performance and high efficiencies were less exacting than at present. New structures and machines were fashioned to a great extent after existing types and models. The advantages of the division of labor and of the transfer of intelligence were but vaguely realized. Emphasis was placed on "what had been done," rather than on adaptability and originality. The writer well remembers the injunction of his professor in machine design which was in substance: 'First get all the catalogues bearing on your design, proportion the parts of your machine after the parts of the old machines, using such devices and arrangements, found in the catalogue, as may seem to meet or suit your requirements.' This procedure is not without merit today in commercial design but to make use of this principle, now, to any great extent, in machine design classes, would defeat the very object for which courses in machine design are given. On the walls of the drawing room of a certain technical school, hangs, at present, assembly drawings of two locomotives. These drawings were made in the late eighties, and in size are, each, about five feet long by three feet wide. The locomotives were designed(?) from pictures in a catalogue. These drawings include about all the work in machine design of the senior class of that time. Machine design of that period had not yet been placed on a scientific basis. Known fundamentals were few. Under such conditions, therefore, the drawing board was about the only medium through which machine design could be imparted to the student.

To-day the requirements in engineering education seem to point, more and more, toward the mastering of principles and fundamentals, rather than specializing too highly in technical details. It could hardly be otherwise with the time now available in the four years of a college course. If a student obtains a fairly good

* Presented at the Conference on Machine Design at the S. P. E. E. meeting in Montreal, June 26–28, 1930.

knowledge of certain fundamentals and some training in their application, he has accomplished about all that may be reasonably expected of him within the four year period of an engineering course.

One of the objects of a course in machine design is to furnish an opportunity, for the student to apply the fundamentals and principles, in the mechanics, to determine proper dimensions and other characteristics of a machine member. An important part in preliminary design is discovering paths of characteristic points, relative displacements, velocities and accelerations. For this purpose the drawing board affords a convenient approach, and should by all means be used whenever possible.. This suggestion, however, applies more particularly to commercial design than to ordinary student work. The work in kinematics, generally precedes the work in design. It should be one of the requirements. The time element prevents a student from making other than a more or less elementary application of the kinematics to design.

A thorough and comprehensive course in theoretical mechanics and in the strength of materials should precede the work in machine design. The student will not, in general, bring from his class work in mechanics to his class work in machine design, many of the principles of mechanics. Unfortunately, it seems, too much emphasis is placed by instructors on periodic quizzes and examinations. The student, therefore, soon arrives at the conclusion that once having passed the requirements, set up by the authorities, regarding grades, he may with propriety feel no further concern about work thus passed. If the student, in some manner, could be brought to realize the importance of mastering fundamentals for use in his life work, rather than for the purpose of passing a final examination, such examinations would be stripped of some of their unpopularity, better records would be made, and the student will have obtained, upon graduation, the highest of values, because of his work in the college class room. Outside of an improved attitude toward his work and better methods of study, the instructor may expect to find little else brought over into his design classes from previous courses. It would seem urgent, therefore, that the instructor should continually remind his students in design work of the basic principles in the mechanics and of their application as progress is made in the design work.

If, then, the purpose of machine design, in a college course, is to provide opportunity for the practical application of the mechanics to designing machinery either as a basis for a profession or for mental training only, it would seem wise to use all the available time for discussion, investigation and problem work in design, covering as wide a range in the mechanics as is possible. The grow-

ing complexity of machinery, to-day, and the higher efficiencies desired, as compared with machines of a few years ago, make it imperative that the designer of the present, have not only a working familiarity with a good hand book (which, if wisely used is a most valuable aid) but also an intelligent appreciation, familiarity and working knowledge of a wide variety of subjects. Accelerations, stresses in rotating parts, stresses due to vibration, elasticity, curved beams, welding and other subjects, must receive consideration by the designer of to-day. A generation ago these subjects may or may not have been given attention in design. To-day, however, these subjects in part or as a whole, are important considerations in economic and efficient designs. Evidently the methods applicable on the drawing board do not lend themselves easily to obtaining mastery; an intensive training and a working familiarity with the above subjects. A careful study of these subjects, from a good text book, under capable instruction, together with the solution of many, *many* practical problems and the making of careful free hand sketches, would appear to have far greater value.

To-day, industry is inclined to separate very markedly, the two functions, design, and drafting. A few years ago, technique, in drafting, was an objective in design. Now, the designer makes his sketches, and applying his fundamentals, determines important dimensions along with other characteristics of his machine or one of the parts. The sketches may then be turned over to a draftsman, who will make a scale drawing from which certain, more or less minor, dimensions may be determined. The designer will supervise the development of the drawing and may suggest changes in design, form, arrangement or method as a result of seeing the machine in a true relation to dimensions. Sometimes the designer may be his own draftsman, but designing and drafting are essentially separate functions.

The use of the drawing board is, of course, a most valuable aid to design in commercial work. However, most engineering students have obtained a fairly good technique in drafting by the beginning of their senior year. It is, therefore, a poor use of the student's time to have him work on the drafting board in order that a slightly better technique may be obtained. This technique may be secured easily, and in a brief time after graduation.

It would seem, therefore, that a student in machine design should be given every opportunity to secure a mastery of the fundamentals and principles in the science, and next, be required to work many problems, whose solution require the application of these fundamentals and principles; and lastly, be required to spend a minimum of time on "lay out" work.

THE DEVELOPMENT OF ENGINEERING MECHANICS

By JASPER O. DRAFFIN

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The ordinary undergraduate course in mechanics is built around basic principles which are few in number but which are extremely important. In presenting this science to the student the teacher should keep in mind the principles as the nucleus of a broad outline or background of the subject and fit the details into their proper place in the scheme. It is sometimes convenient to distinguish between the principles themselves and the tools used in applying the principles to practical problems.

The *tools* used both in analysis and in application are mathematics, graphical and algebraical. In discussing them and the men who are mainly responsible for their development, reference will be made to those men who have either originated or made significant contributions to engineering mathematics.

The first of these is Euclid (330–275 B.C.). Little is known of the personal life of this man but he prepared a treatise on plane and solid geometry, the twelve books of Euclid, which has been the foundation of our mathematical reasoning since that time. From a few axioms (as Euclid and earlier generations called them), postulates, and definitions was built up a complete set of proofs for numerous propositions. It seems probable that he merely compiled the material from various sources but, if so, the editing was done very carefully. In the same general period with Euclid is Hipparchus, a Greek astronomer of about 140 B.C. He is credited with having invented trigonometry and working out what is supposed to have been the first table of trigonometric functions.

After a lapse of about nineteen hundred years another man came on the scene of engineering mathematics. This was John Napier of Merchiston (1550–1617), a Scotchman who published his invention of logarithms in 1614. With him must be placed the Englishman, Henry Briggs (1561–1631), who made logarithms a really usable tool for engineering work by devising the common system of logarithms to replace or supplement those calculated from the Naperian base. The amount of labor which these men have saved engineers and scientists, especially through the graphical use of logarithms, *i.e.*, the slide rule, is almost incalculable. If we but consider that the gap between the invention of trigonometry

and that of logarithms is about the same in time as that between the destruction of Carthage and the Pilgrims landing at Plymouth it may serve to show the lack of mathematical accomplishment during the middle ages.

Our attention is next attracted to René Descartes (1596–1650), the great French philosopher who invented analytical geometry. It is probable that today only a relatively few people would have the patience to interpret his exposition of the subject because Descartes' presentation would hardly be called popular in this day of appeal to the eye and ear rather than to the reason. But a few rare minds analyzed Descartes' work and expressed it in a manner more readily understood than his own presentation of it and thus was born and grew that great tool of mathematics.

It is difficult to select any one individual who contributed so basically to algebra as applied to engineering that he can be given special mention. Yet, it seems that the Englishman John Wallis (1616–1703) is such a man. Previous to his writings the relationship between a number of quantities was expressed as a proportion or ratio but Wallis expressed the relationship between quantities in a form similar to the familiar equation we have today. While many may regret the too unthinking application of formulas, their proper use has made computation much simpler than it used to be. In fact without formulas it is difficult to understand how the multitudinous computations of engineering could be made.

While William Penn colonized Pennsylvania, two men, the Englishman Sir Isaac Newton (1642–1727), and the German G. W. Leibnitz (1646–1716), labored, achieved, and later wrangled with each other. For to each of these men came the thought that flux or change might be expressed mathematically and this idea grew under their skillful hands into that mightiest tool of the engineer and scientist, the differential and integral calculus. So accustomed to its use are we that it is rather difficult for us to appreciate the fact that calculus has not always been a ready instrument for the hand of man, however unskillfully some of us may use it.

The latest addition to our tools in mechanics is graphics or graphical analysis. The basic idea in graphics goes back to Stevinus who introduced the notion of vectors or the representation of a force by a directed line. Culmann (1821–1881) devised the string polygon as a working method for the solution of force systems and James C. Maxwell (1831–1879), in 1864, extended the application of the equilibrium polygon by bringing the separate polygons needed for each joint of a truss into a single diagram for the whole truss.

Before much progress can be made in arranging a method for the application of the principles of mechanics there must be some

scheme of reference points or a system of coördinates. An arrangement which allows a force or other vector quantity to be broken into parts, or a complicated motion into simpler parts, permits the handling of each element separately and thus facilitates the analysis of the force system. Of course these ideas were in the minds of many of the earlier workers, such as Stevinus, Galilei, Newton and others, but Euler (1707–1783) seems to have been the first to resolve formally a force into its components. He did this in the case of curvilinear motion by resolving a force into tangential and normal components in 1736 in his "Mechanica sive Motus Scientia Analytice." The next step was taken by Maclaurin in 1742 when, for the first time, he resolved a force into x and y components. This apparently fixed the mold for the future use of coördinates. In 1726 Daniel Bernoulli (1700–1782) fashioned a powerful tool for the study of motion when he resolved plane motion into a rotation and a translation and dealt with each separately.

We turn now to the *principles* of mechanics and their originators. First, of course, is Archimedes (287–212 B.C.), that Sicilian genius who was really a mechanical engineer at heart but who would have scorned such a designation because of the spirit of the times. He discovered some of the principles of hydrostatics and laid the foundation of our knowledge of mechanics. His system was mainly one of statics and it was founded on the *law of the lever.* This of course logically includes the topic of centroids, since the latter is merely a particular example of moments. The law of the lever or the moment of a force persisted as the principal mode of thought in mechanics for nearly nineteen hundred years. It is remarkable that the beginnings of mechanics should be so close to those of mathematics and that both of these should lie dormant for a long period and then awaken at the same time, statics in 1586 and logarithms in 1614, and march along together. It is true that the artist Leonardo da Vinci (1452–1519), a century earlier, showed a knowledge of a number of cases of statics but it is a long step from a few scattered ideas to a systematic and logical arrangement of principles into a single unit and therefore the ideas of da Vinci cannot be considered as a significant advance.

After Archimedes the scene of the next forward movement in statics was in Holland in 1586 when the Flemish writer Simon Stevinus (frequently written Stevin) (1548–1620) presented his famous work on statics entitled "De Beghinseln der Weegheonst" (Principles of Equilibrium) which was translated into Latin in 1608 and published as a part of his collected works entitled *Hypomnemata Mathematica,* and translated into French in 1634. Stevinus used the *inclined plane* or wedge as the basis of his statics

and developed its use to a remarkable degree. Reasoning from the readily accepted proposition that an endless chain hung over a triangular prism with the lower edge horizontal would not slide either way, he reached correct conclusions regarding the equilibrium of bodies on inclined planes. Though Stevinus used the principle of the parallelogram of forces, he did not expressly formulate a statement of the principle. He was, as previously noted, the first to represent forces by means of lines, *i.e.*, vectors, and was the first to introduce decimal fractions into regular use. He was a military engineer of considerable ability, an inventor, and an influence in promoting the improvement of the methods of public accounting.

Thus forces and their manifestations were presented from two different points of view by Archimedes and Stevinus, the earlier presentation being that of the tendency of forces to cause (or hinder) rotation and the later one that of the tendency of forces to cause or hinder translation. But as yet each problem which arose was dealt with separately; generalizing about forces and thus making the laws useful in a large number of cases had not yet been done in any comprehensive way. Machines and structures had not yet become complicated and therefore the application of known principles had not been extended very greatly.

The work of Stevinus though highly original did not exert a great influence during the life of the author partly because the time for his work was not ripe. A century later, in that period when interest in mechanics was much more intense under the influence of Huygens, Newton and others, Pierre Varignon (1654–1722) wrote a book on mechanics. His book contained little that was original in principle, being based on Stevinus' work, but he arranged and systematized statics into virtually the form it has to-day. The reader of Varignon is impressed, particularly by the diagrams, that he was interested in the applications of mechanics rather than in the abstractions. He added one important idea, viz., the *principle of moments,* or Varignon's Theorem as it is sometimes called. It is merely an extension of the principle of the parallelogram of forces to the moment of these forces. This idea, the principle of moments, was presented by Varignon in 1687 and also presented in the same year, but independently, by Bernard Lamy (1640–1715). Later, in 1818, Louis Poinset (1777–1859) added to our store of knowledge of moments or rotation by bringing out the theory of couples and their transformations.

Yet with all of the theory which had been evolved there was, a century ago, in some cases, a paucity of knowledge of application. Though Varignon showed plainly in 1687 the methods of vectorial addition of forces and the conditions which governed the equilib-

rium of a number of concurrent forces, there seems to have been no adequate analysis of a truss until Squire Whipple (1804–1881), of Albany, N. Y., in the early part of 1847, published a pamphlet giving an *analysis of trusses.* This pamphlet, of which only fifty or sixty copies were distributed, was supplemented by a second part and in the latter part of the year 1847 the two "Essays" were published as the first edition of a book, small in size, bearing the descriptive title "A Work on Bridge Building consisting of Two Essays, the One Elementary and General, the Other giving Original Plans, and Practical Details for Iron and Wooden Bridges." Whipple conceived the idea of taking each point where the truss members intersected (a joint) and by considering that point as being in equilibrium he was able to compute the stress in the intersecting members, surely a simple and easy procedure. August Ritter of Germany completed the simpler applications of statics in 1856 when he extended the methods of truss analysis by introducing the "method of sections" which is merely a case of the equilibrium of coplanar non-concurrent forces.

What of the science of moving bodies, kinetics? The number of people who have added to the sum total of our information on kinetics is large and yet there are a few men who stand head and shoulders above all others as the founders and discoverers of great principles. The first of these is Galilei (1564–1642) who founded the subject of kinetics. Galilei was not content to accept the current ideas of his day and so he studied, experimentally as well as analytically, the *motion of a particle.* From him the world gained its first real knowledge about the way a particle moves.

The knowledge of motion which Galilei inherited from the past was practically worthless. The Aristotelian view was that heavy bodies fell faster than light ones and they did so because all things occupied a prescribed place in the universe and naturally each body or particle took the place which belonged to it; the mechanics of that time was a species of metaphysics. Now Galilei did not inquire *why* bodies moved but *how* they moved. He says "The present does not seem to be the proper time to investigate the cause of the acceleration of natural motion . . ." and then follows this by saying "At present it is the purpose . . . to investigate and to demonstrate some of the properties of accelerated motion. . . ."* Galilei determined experimentally the laws which govern the motion of falling bodies and of projectiles and therefore his mechanics was mainly that of kinematics since he emphasized the acceleration rather than the forces which caused acceleration or the properties of the body which was accelerated. He experimented with balls

* Dialogues Concerning Two New Sciences, trans. by Henry Crew and Alfonso de Salvia, p. 166, Macmillan, New York.

rolling down grooves in an inclined plane and measured the time by weighing the amount of water which flowed from an orifice under a nearly constant head. Two items of extreme importance are found in his work; first, the contribution which he made to the knowledge of the laws governing the action of a particle and, second, the subjection of mechanical principles to experimental proof.

The prophetic mantle of Galilei was put aside to be laid later upon the shoulders of Christian Huygens (1629–1695), the Dutchman who added to the work of Galilei about thirty years after his death by bringing out the essential facts concerning the *motion of a rigid body*. He solved the problem of the center of oscillation by means of the principle which he set forth that the center of gravity of a system of particles would rise as high as the point from which it fell, and he introduced the concept of work and energy into mechanics. The pendulum clocks of to-day are based upon the work done by Huygens over two hundred and fifty years ago. There is a difference of opinion among authorities as to whether or not he had a clear understanding of mass but, be that as it may, he is the second great figure to appear in kinetics.

It is unnecessary to say much about Newton who in 1687 gave to the world his *Philosophiæ Naturalis Principia Mathematica;* his mind is one of the greatest of all time. Rather curiously the demonstrations and analyses in this monumental book were all geometrical though his work on the calculus was complete before the Principia was written. In this treatise the special cases treated by others are seen to be but shoots from the main stem, which main stem is undergirded by his "Three Laws of Motion." What powerful tools these generalizations of the laws of motion are! Newton was the first to present clearly the *notion of force* as it is held to-day and he clarified and crystallized beyond all dispute the *concept of mass*. Even if Einstein does modify our conception of the laws which govern the universe it still will hardly affect the applicability of "Newton's Laws" to the problems of engineering mechanics.

The motion of a body may be expressed in different ways. Galilei and Newton presented their ideas in terms of force while Huygens used the concept of energy. Since the relations existing between force, velocity, space, and time were very imperfectly understood by the average student, the subject of kinetics was much confused in the early part of the eighteenth century because of these two ways of expressing or describing motion. Two factions, one the followers of Descartes and the other of Leibnitz, maintained for years a dispute over the proper measure of the "force of a body in motion"; the "Cartesians", as they were

called, claimed that the force varied as the first power of the velocity (mv) while the adherents of Leibnitz claimed that the force varied as the second power of the velocity (mv^2). This confusion was dispelled forever by the Frenchman D'Alembert (1717–1783) when he clearly showed in the preface to his "Traité de Dynamique," 1743, that force did not reside *in* a moving body but was related to the difficulty of *stopping* a moving body and that it (force) was the measure of the amount of obstacle or impediment which the moving body might overcome. Thus he showed that the velocity of a body, under a constant force, varies as the first power of the velocity with respect to time, *momentum,* and as the second power with respect to distance, *kinetic energy.* This clear statement settled the dispute between the two factions and brought order out of chaos. D'Alembert evolved no new principles but made two great advances in kinetics. He showed that the sum of the eternal forces in a body is equal to zero, and may therefore be neglected, and, by the introduction of a reversed effective force, which is simply the application of the third law of motion, he reduced kinetics to statics. His great contributions were therefore the reduction of the kinetics problem to a simpler one of statics and the clarification of the confusion between energy and momentum. Our present treatment of kinetics is essentially that of D'Alembert; he helped to make kinetics an engineering tool.

One more principle or concept should be mentioned, even though it is usually omitted in the undergraduate course, that of *virtual work.* This was presented by the Swiss mathematician John Bernoulli (1667–1748) and later expanded into an elegant and comprehensive system by the Italian mathematician, L. J. Lagrange (1732–1813). In this system analytical mechanics has been brought to its highest state of perfection but not every engineer has the mathematical ability to handle its abstractions. Michael Pupin in his "From Immigrant to Inventor" pays high tribute to the latent power in Lagrange's "Méchanique Analytique."

Thus far we have come. The great *principles* which govern the motion and equilibrium of bodies in engineering work are well known. But the ramifications of the *applications* of these general principles are by no means all known. New applications are being made day by day, as, for instance, in statics the forces (stresses) acting in thin plates, and in kinetics the forces produced by vibration. Great laws are general and abstract but their application is specific and concrete. Surely we shall continue to have D'Alemberts, Huygens and Varignons who will extend the boundaries of our knowledge of mechanics and make the applications which are needed in our complex engineering problems.

AERIAL PHOTO SURVEYING AND MAPPING *

By S. D. SARASON

Professor of Civil Engineering, Syracuse University

Very few of our schools include Photographic Surveying in their Civil Engineering curriculum, and a still smaller number have attempted to teach Aerial Photographic Surveying.

Terrestrial Photo Surveying with a Photo Theodolite has been practiced to a limited extent for many years. There is included in the 1897 Report of the U. S. Coast and Geodetic Survey an Appendix "D" by J. A. Flemer describing this method. It was then being used in the Survey of Southeastern Alaska. Mention is made in that report of the possibility of attaching a Camera to a free or a captive balloon.

The airplane has greatly widened the field of application of Photographic Surveying. The European techical schools have taken the lead in this field both in their publications as well as in devising instruments for the practical application of this new method of Surveying. The European schools have a separate course for Topographic and Geodetic Engineering and another for Structural Engineering. We combine both in our Civil Engineering course. Due to the broadening of our Engineering curriculum by the introduction of cultural, business, economic and other allied subjects, specialized technical courses such as Photographic surveying were eliminated.

A course in Terrestrial Photographic Surveying has been given continuously at Syracuse University since the founding of the College of Applied Science. A generous contribution to our University last year from the Guggenheim Foundation for the Promotion of Aeronautics, made it possible to introduce new courses in Aerial Photo Surveying which are offered as optional courses in the last two years of the Civil Engineering curriculum.

Fig 1 shows an outline of the last two years of Course 1, Civil Engineering, and Course 1-A, Civil Engineering (Aerial Photographic Surveying Option). It will be noted that only the *advanced* courses in Minerology, Steel Design, Masonry Design, and Hydraulics are permitted to be omitted from the regular Civil Engineering program. A student is not required to take all the pre-

* Presented at the 38th Annual Meeting, S. P. E. E., Montreal, Canada, June 26–28, 1930.

scribed courses in Course 1-A, but may elect any course for which he has the necessary prerequisites. These new courses are open as electives for all Engineering students as well as for other students of the University who have the necessary preparation.

COURSE I

CIVIL ENGINEERING

Junior Year

Summer Surveying Camp (C3 and C4)

FIRST SEMESTER	Hrs.
Elements of Structural Engineering (S.D. 2)	3
Hydraulics (H. 1)	3
Hydraulic Laboratory (H. 21)	1
Materials Testing (M.L. 6)	1
Mechanics of Materials (S.D. 1)	5
Metallurgy (Chem.E. 6)	1
Mechanical Laboratory (M.L. 3)	1
Railroad Design (R. 23)	1
Steam Engines (H.P. 1)	3
Structural Design (S.D. 20)	1
Total	20

SECOND SEMESTER	Hrs.
Photo Surveying (A.P. 4)	3
Geology (Geol. 2b)	3
Cement and Concrete Testing (M.L. 7)	1
MINERALOGY (MIN. 9)	3
Railroad Bridge Design (S.D. 3)	5
Structural Design (S.D. 21)	2
Water Supply and Sewerage (H. 3)	3
Water Supply and Sewerage Design (H. 22)	1
Total	21

Senior Year

Summer Surveying Camp (C. 5) Elective

FIRST SEMESTER	Hrs.
BRIDGE AND BUILDING DESIGN (S.D. 22)	1
BRIDGES AND MILL BUILDINGS (S.D. 4)	3
Business English (Bus. Eng. 9)	2
Economics (Econ. 1)	3
ELECTIVE	3
Reinforced Concrete Bldg. Design (S.D. 23)	1
Principles Elec. Engineering (E.M. 5)	3
Reinforced Concrete (S.D. 5)	3
Selected Experiments in Elec. Engineering (E.L. 5)	1
Total	20

SECOND SEMESTER	Hrs.
Economics (Econ. 1)	3
ELECTIVE	3
Engineering Law (Bus.Law. 1)	2
HYDRAULIC MOTORS (H. 4)	3
Principles Elec. Engineering (E.M. 6)	3
MASONRY (S.D. 6)	3
MASONRY DESIGN (S.D. 24)	1
Selected Experiments in Elec. Engineering (E.L. 6)	1
HYDRAULIC LAB (H 22)	1
Total	20

COURSES IN CAPITAL LETTERS ARE OMITTED IN COURSE 1-A

COURSE 1-A

CIVIL ENGINEERING
(Aerial Photographic Surveying Option)

Junior Year

Summer Surveying Camp (C3 and C4)

FIRST SEMESTER	Hrs.
Elements of Structural Design (S.D. 2)	3
Mechanics of Materials (S.D. 1)	5
Metallurgy (Chem. E. 6)	1
Steam Engines (H.P. 1)	3
Railroad Design (R. 23)	1
Mechanical Laboratory (M.L. 3)	1
Structural Design (S.D. 20)	1
MAP PROJECTIONS (A.P. 1)	2
OPTICS (A.P. 2)	3
Total	20

SECOND SEMESTER	Hrs.
Geology (Geol. 2b)	3
Railroad Bridge Design (S.D. 3)	5
Cement and Concrete Testing (M.L. 7)	1
Structural Design (S.D. 21)	2
Materials Testing (M.L. 6)	1
Business English (Bus. Eng. 9)	2
GEODESY (A.P. 3)	3
Photo Surveying (A.P. 4)	3
Total	20

Senior Year

Summer Surveying Camp (C. 5) Elective

FIRST SEMESTER	Hrs.
Economics (Econ. 1)	3
Reinforced Concrete (S.D. 5)	3
Principles Elec. Engineering (E.M. 5)	3
Hydraulics (H. 1)	3
Reinforced Concrete Bldg. Design (S.D. 23)	1
Selected Experiments in Elec. Engineering (E.L. 5)	1
Hydraulics Laboratory (H. 20)	1
AERIAL PHOTO SURVEYING (A.P. 5)	3
AERIAL NAVIGATION (A.P. 7)	3
Total	21

SECOND SEMESTER	Hrs.
Elective (H. 4 and H 22 or S.D. 6 and S.D. 24)	4
Economics (Econ. 1)	3
Engineering Law (Bus. Law 1)	2
Principles Elec. Engineering (E.M. 6)	3
Water Supply and Sewerage (H. 3)	3
Selected Experiments in Elec. Engineering (E.L. 6)	1
Water Supply and Sewerage Design (H. 22)	1
AERIAL MAP CONSTRUCTION (A.P. 6)	3
ECONOMICS OF AERIAL MAPPING (A.P. 8)	1
Total	21

AERIAL PHOTOGRAPHIC SURVEYING COURSES NOT GIVEN IN REGULAR CIVIL ENGINEERING COURSE ARE SHOWN IN CAPITAL LETTERS

FIG. 1.

The course in Aerial Navigation had the largest registration. Many students elected it as a preparation for an Air Pilot's license. The students in Aerial Navigation received instruction in the use of navigating instruments and astronomical calculations for half of the semester in the Civil Engineering Department and the remainder of the semester was spent in the Electrical Engineering Department and in the University Meteorological Department where instruction was given in the use of the radio compass and radio beacons, and the interpretation of meteorological forecasts. This unusual method for dividing a student's time in a single course in three departments proved quite satisfactory.

Our Faculty Committee on the arrangement of these new courses as well as on the purchase of equipment was assisted by an Advisory Committee consisting of Captain Emory S. Land of the Guggenheim Foundation, J. B. Beadle of the Brock & Weymouth Co., Carl S. Bausch of the Bausch & Lomb Co., Col. Claude H. Birdseye of the Aerotopograph Corporation of America, and E. R. Polley of the Fairchild Aerial Surveys. The University is greatly indebted to this Committee for its valuable assistance.

It is necessary to outline the various types of Aerial Surveys which are now being executed, before attempting to suggest the necessary equipment required to teach these courses.

The Federal Bureau of Aeronautics lists 162 companies engaged in aerial mapping. On closer examination it is found that most of these are commercial aviation companies, who do occasional aerial photography incidental to their other activities. Such companies generally make either a single photograph of a small area, or a mosaic of a larger area, consisting of a series of photographs, reduced as nearly as possible to the same scale, and properly oriented. When sufficient ground measurements are available, and for areas of moderate relief, a mosaic may be made of fairly high degree of accuracy. Mosaics are very useful for planning engineering work and most of the aerial mapping done in the United States is of this type.

The Canadian Government has made extensive use of oblique aerial surveys in mapping their vast inaccessible areas of forest and lake country which is generally of very low relief. The distance of the horizon line from the centre of the plate permits the calculation of the tilt of the camera. The focal length of the lens and the height of the camera are the only addditional data necessary for compiling a plotting grid, by the principles of perspective geometry, by which line maps may be constructed from the oblique views. These Canadian aerial maps are published on a scale of 4 miles to the inch and resemble our Geological Survey maps except

that no contours are shown. The Canadian Government is also using aerial photography for reconnaissance for triangulation in their Geodetic Survey.

The equipment necessary for the construction of Mosaics as well as line maps by the Canadian method consist of an aerial camera, a rectifying camera, and apparatus for developing and printing photographs. Arrangements can be made with a commercial Aviation company for the necessary flying. It is even possible to obtain photographs from commercial photo aerial mapping companies for instruction purposes, and no special equipment would be required. A course in Terrestrial Photo Surveying should precede the instruction in aerial methods. A photo theodolite would be required for this work.

There will undoubtedly be an increasing demand for mosaic or pictorial maps made from aerial photographs. Their low cost as well as their richness in detail can not be duplicated by any other method of surveying. However the construction of mosaics involves more of photographic art than engineering.

The field of aerial mapping which is still in the process of development is its economic application to the construction of topographic maps. Considerable research is still required in this field.

The U. S. Geological Survey has used for some time aerial photographs to supplement their usual land methods. In recent years they have done considerable experimental work in aerial photography, and they are expecting to issue in the near future, topographic maps compiled from aerial photographs instead of planetable sheets. The U. S. Coast and Geodetic Survey is also using aerial photo surveying methods in an increasing amount. It is expected that topographic mapping of large areas on scales comparable to those used by the U. S. Geological Survey and topographic maps of smaller areas on larger scales, in difficult and inaccessible territory, will be executed by aerial photo methods in less time, more accurately and cheaper than by the standard ground methods.

The following instruments were imported by our University from Germany and were used to instruct our students in the application of aerial photo surveying to topographic mapping.

Fig. 2 is a comparator by which the horizontal coördinates of points on a single photograph may be accurately measured. A Bulletin by Professor Church recently published by our University describes the analytical solution of the problem of topographic mapping from comparator measurements on aerial photographs. It is possible to calculate elevations of points appearing on two overlapping photographs.

Fig. 3 is a stereo-comparator. Two overlapping photographs which have been horizontalized by a rectifying camera, are viewed stereoscopically in this instrument. For points appearing on both photographs it is possible to measure the two horizontal coördinates

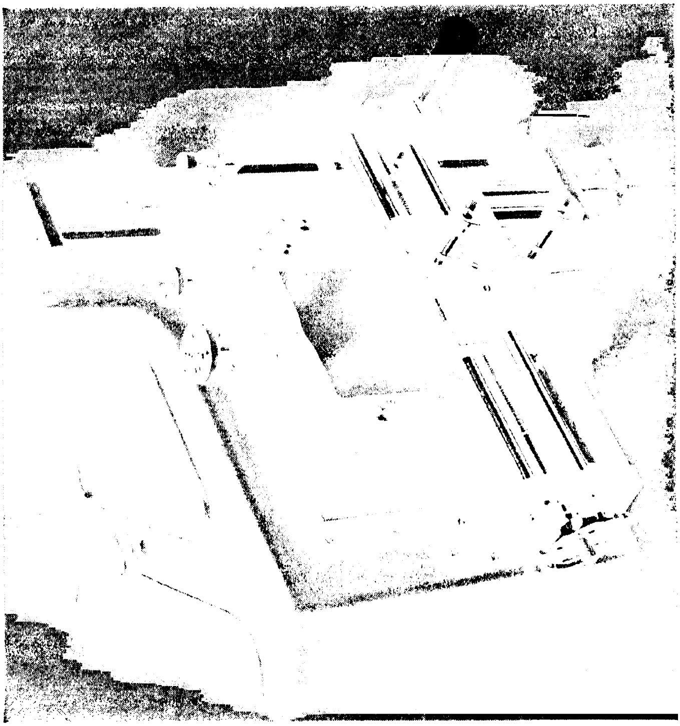


FIG. 2.

as well as the parallax, from which the vertical coördinate may be readily calculated. The principle of the stereo-comparator is used by the Brock & Weymouth Co. in their stereometer for drawing contours directly on the photographic plate.

Fig. 4 is a photogoniometer for measuring angular values on a single photograph with respect to the optical coördinates of the plate.

The aerocartograph is a German plotting machine for aerial topographic mapping, in which two photogoniometers are used in conjunction with a pantographic plotting device. There are sev-

eral other European plotting machines for aerial topographic mapping of which might be mentioned the Wild Autograph made in Switzerland, and the Zeiss Stereo Autograph, made in Germany. It was the opinion of our Advisory Committee that it would be preferable for instruction purposes to acquire the instruments previously listed rather than any of the automatic plotting ma-

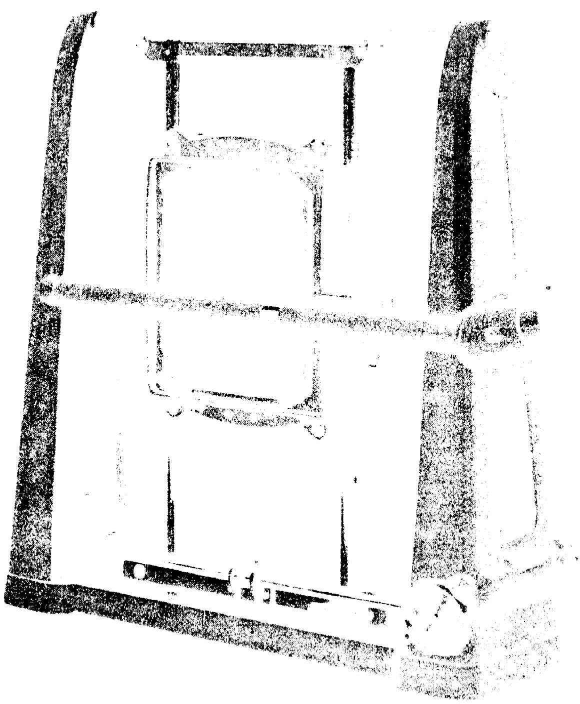


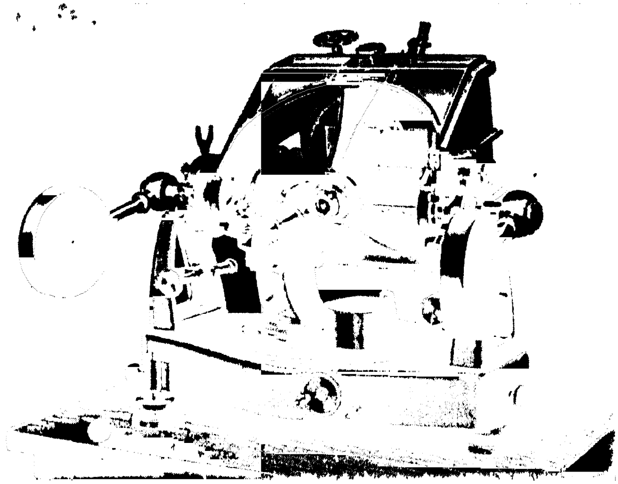
FIG. 3.

chines mentioned. There are several of these machines now being used in this country which can be inspected by our students after they have studied the principles upon which these machines depend. The present models are being constantly improved and it is difficult to predict as to what will be the ultimate solution of the application of aerial photo surveying to topographic mapping.

There are comparatively few schools which give comprehensive courses in aeronautical engineering, a specialized branch of Mechanical Engineering. It is therefore not expected that all technical schools will give a complete program of instruction in aerial photographic surveying. However engineering students should be familiarized with the various types of aerial maps and their economic application to various engineering projects.

PHOTO GONIOMETER

Bildmeßtheodolit
nach Prof. Dr.-Ing. Hugershoff
Patentiert in den meisten Kulturstaaten



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Bildformat 13 × 18 cm, f = 18 cm
FIG .4.

At the present time most of the aerial photographic surveying and mapping is being done by the contract method, involving a lump sum bid for a certain project. There is an urgent need for standardized specifications for this work to insure fair and equitable bidding. It is hoped that a technical committee for this purpose will soon be organized. The Committee on Standardization of Technical Nomeclature of this Society could be of considerable assistance in assigning suitable names to the various types of so-called aerial maps now being produced.

REPORT OF THE MEETING OF THE INSTITUTIONAL DIVISION

As set up in the program of the Thirty-eighth Annual Meeting of the Society for the Promotion of Engineering Education, the Institutional Division held its session at 2:30 P.M., June 28, 1930, in Moyse Hall, Arts Building of McGill University. The Division program was modified somewhat by the addition of a report by H. H. Higbie on Engineering Research Subjects Suggested by Industries, and one by C. Francis Harding on Advantages and Disadvantages of Co-operative Research Projects With Industries, supplementing the report by R. A. Seaton on Engineering Research at the Colleges and Universities of North America. These three reports together constitute the report of the Society's Committee on Engineering Research for 1929–30. Dr. J. H. Parkins, of the National Research Council of Canada, presented the discussion of F. E. Lathe, the Director, and Dr. T. C. Fry substituted for John Mills of the Bell Telephone Laboratories.

Report of the Executive Committee

The Institutional Division for 1928–1929, Dean C. C. Williams, Chairman, made certain recommendations which were accepted by the Society Council at its meetings June 18 to 21, 1929. This action resulted in the creation of executive committee of the Division. The committee appointed consisted of, C. C. Williams, I. C. Crawford, Louis Mitchell, S. B. Earle, G. W. Case, H. M. MacKay and E. A. Hitchcock, Vice-President, for Chairman.

Another recommendation of the Division, and accepted by the Society Council, was the appointment of a committee of the Division "to study and report on the propriety of extending the institutional membership of the Society to non-collegiate institutions." This study was referred to the executive committee of the Division rather than to a separate committee. Due to pressure of required work, and interference over which he had no control, the chairman did not take up this matter with the executive committee. Therefore a new committee has a clear field and will not be hampered by any partial study by a previous group. Our recommendation, however, would be that this study be referred to a separate committee, which is the inference in the action taken by the Division June 20, 1929.

During the latter part of the year 1928–1929 your Executive Committee discussed, through correspondence, an educational question which was looked upon as of such importance as to merit further discussion, with a possibility of recommending its investigation to the Division. The committee, therefore, held a meeting at 10:00 A.M. June 28 at McGill University at which C. C. Williams, I. C. Crawford, H. M. MacKay and E. A. Hitchcock were present. This meeting resulted in this recommendation or suggestion to the Division, or its new Executive Committee, that the following topic or project be referred to a committee for investigation and study:

The subject proposed is "Coöperation between Industry and the Engineering Teacher." The particular phase of this subject to be investigated is, the employment of teachers by industry. The period of employment should be for one year, the teacher to have this opportunity every four or five years. The points raised in the discussion were as follows:

1. The desirability and value of such coöperation was beyond question.

2. The responsibility of industry to engineering education should be so recognized by it as to make such coöperation possible. While it is a fact that there are a few industries which are making possible such opportunities their number is small in comparison to the number of engineering teachers.

3. To make this coöperation possible, industry and college should combine on the matter of compensation. The great majority of engineering teachers could not afford to make financial sacrifices on account of family responsibilities.

4. While employment of teachers during the summer vacation is highly desirable, such individuals would be more valuable to industry if their period of service covered 12 or 15 months.

5. Certain teachers might be able to render a peculiar expert service to some industry, the value of which would be comparable to the teacher's salary and, therefore, no embarrassment would arise in this direction.

6. There was doubt expressed as to whether industry would be sufficiently philanthropic to pay teachers more than they would earn. Generally this should be so, due to recognition of responsibility. Better teachers produce better graduates for industry.

7. The chance of a teacher going to another institution after his period of experience and, therefore, that institution reaping the benefits derived by him and made possible by his university's coöperation. This point would be met if the system should be employed generally.

8. The possibility of the teacher obtaining credit in a graduate school on account of the character of the work carried on in industry.

9. The promotion and advancement in salaries of engineering teachers to be dependent, to a large degree, upon these contacts, and practical experiences, governed somewhat by the extent to which their value as teachers has been increased.

Respectfully submitted,

EXECUTIVE COMMITTEE OF THE INSTITUTIONAL DIVISION

C. C. WILLIAMS,
I. C. CRAWFORD,
H. M. MACKAY,
E. A. HITCHCOCK, *Chairman*

REPORT OF COMMITTEE ON GRADUATING PERSONNEL

Your Committee on Graduating Personnel of the Institutional Division of the Society for the Promotion of Engineering Education begs to make the final report on its work. The committee made a preliminary report at the meeting in Columbus in 1929 and during the present year it has collected further data for its work.

The committee was appointed on December 28, 1928, and it was directed to study the subject: "Recognizing Native Executive Ability."

Our instructions contained the following:

The following procedure is suggested. It may be modified or amplified at the discretion of the committee.

1. What, if any, are the evidences of latent or embryonic executive or managerial aptitude manifest and recognizable in engineering students?

a. Correlation between scholastic achievements and success in executive or managerial positions in industry.

b. Ditto between scholastic achievement plus participation in student activities, (*a*) student organizations offices, (*b*) student enterprises, (*c*) athletics, (*d*) social and executive success in industry.

To be of most discriminative value, the success or failures should be of a certain number of cases (say 50) of men who had made good as executives and a similar number of those who had been definitely *given a chance* and failed. Studies made by United States Army would be pertinent.

2. If native executive aptitude could be identified with a reliability of say 75 per cent in senior students at time of graduation, to what extent would such knowledge be definitely usable by industries under present personnel methods? Under possible revision of personnel methods?

The committee has used data from three industrial companies and from classes of 1912 and 1916 of two engineering schools. As

stated in our last report, the returns from the industrial organizations record the achievement of men from different schools in industry, while the college replies give us the records of the graduates of definite institutions in different industries.

In the industrial group the study has included the examination of men who have achieved success as measured by the responsibility of their work and their positions in salary scales, and also the record of certain men who had entered with the same possibility of achievement but who have not been advanced in responsibility and salary.

In the school list, success has been measured by responsible positions and amount of salary, and the men have been divided into the same two groups.

It has not been possible to receive and publish the salaries received by the men in industry, although the men have been placed by those contributing the information into relative salary groups; and from the schools it has been thought unwise to give any relative figures regarding salary.

In making this study the committee has endeavored to collect the following data:

Class Standing:
- Upper Tenth.
- Upper Third (Outside Upper Tenth).
- Middle Third.
- Low Third.

Campus Activities in:
1. Athletics.
2. Social.
3. Literary.
4. Music.
5. Managerial.

The amount of achievement in these activities is graded as follows:

Substantial,
Some,
None.

Earnings during student days in amounts according to above table.

Summer work of student days in amounts according to the above table.

Position held at various times.
Salary at end of each two year interval.
Civic activities.
Size of family.
Systematic study since graduation.

The data under the last five heads have not been obtained in all cases.

The committee, in fixing success in executive work, has determined upon using the nature of the position held at present together with the relative salary within the organization as a measure of success. It has also endeavored to confine itself to those who have distinctly executive positions. It is found that much of the data received varies in such a way that merely the trends are disclosed, and it is interesting to note that these trends bear out the conclusions already arrived at by Colonel R. I. Rees in his excellent report made two years ago.

The present report is based on the records of 108 successful men and 41 unsuccessful men from industry, and 58 successful and 18 unsuccessful men from the classes of 1912 and 1913 from two engineering schools.

Scholastic Standing

In industry 27 per cent of the successful men stood in the upper tenth of the class, 40 per cent in the remaining part of the upper third, 26 per cent in the middle third, and 7 per cent in the low third. Of the unsuccessful men 5 per cent were from the upper tenth, 25 per cent in the remaining part of the upper third, 34 per cent in the middle third, and 27 per cent in the low third, and 9 per cent were not classified.

From the record of the engineering schools the following is found:

	Successful Men	Unsuccessful Men
Upper tenth	12%	6%
Remaining upper third	31	11

	Successful Men	Unsuccessful Men
Middle third	31%	28%
Low third	26	55

From the above it is seen that in industry over two-thirds of the successful men have been in the full upper third of their classes, and from the colleges a little under one-half of the successful men were in the full upper third.

The data from industry show that about one-third of the unsuccessful men had scholastic promise by their position within the upper third. Only 7 per cent of the successful men were in the lowest third, while 27 per cent of the unsuccessful men were drawn from this group. If the men with reported standing be considered, this percentage becomes 30 per cent.

Of those from the group of upper tenth men, the successful men number three times the unsuccessful men from the group.

Opinion of Faculty

The school records indicate that Faculty opinion has a predictive value for of the 58 successful men 73 per cent were judged to have executive ability, and of the 18 unsuccessful men 78 per cent were rated as having no executive ability.

College Earnings

The earnings during college days are of little value as means of predicting future success, as is seen from the table below:

	School Data		Industry Data	
	Successful Men	Unsuccessful Men	Successful Men	Unsuccessful Men
Substantial..........	23%	50%	25%	30%
Some...............	27	19	52	46
None...............	50	31	23	24

These data from the schools seem to indicate that fewer successful men have had earnings during their college course than the unsuccessful men, while in industry the percentage is about the same in the two classes with the unsuccessful men earning the greater amount.

Work During Summers

The record of work during the summer vacations (where reported) results in the following table:

	School Data		Industry Data	
	Successful Men	Unsuccessful Men	Successful Men	Unsuccessful Men
Substantial..........	38%	61%	38%	5%
Some...............	43	33	30	19
None...............	19	6	32	76

Of the successful men about 40 per cent have done substantial work during the summer in each group, while for those who have done some work and no work, the records from type schools and from industry differ. When the records of unsuccessful men are considered it is seen that the distribution from industry is opposite that from the schools.

Campus Activities

The school records do not give full data on the subject of campus activities. The data from industry result in the table below:

	Data from Industry	
	Successful Men	Unsuccessful Men
Substantial	30%	5%
Some	36	34
None	34	61

From this list there appears to be a trend indicating that campus activities are in some way indicative of future success, although it is rather the substantial achievement and the absences of any campus activity which are the predictive factors. The men who merely do some extra curricula work may be found later in either group while those who have had substantial campus achievement will probably be found among the successful men.

High Stand Men

An examination has been made of the records of men included in the upper thirds of their classes so as to see if there are any peculiar trends in this group. The following tables result:

Data from Men in the Upper Third Scholastic Group

CAMPUS ACTIVITIES—DATA FROM INDUSTRY

	Successful Men	Unsuccessful Men
Substantial	28%	3%
Some	36	34
None	36	58

Summer Work

	College Data		Industry Data	
	Successful Men	Unsuccessful Men	Successful Men	Unsuccessful Men
Substantial	21%	66%	51%	0%
Some	50	34	21	50
None	29	0	28	30

Earnings

	College Data		Industry Data	
	Successful Men	Unsuccessful Men	Successful Men	Unsuccessful Men
Substantial	19%	66%	31%	23%
Some	24	0	46	54
None	57	34	27	23

The data of campus activities of the high stand men are practically of the same relative percentage in the degrees of achievement as is shown by the data of all men. This indicates that relative participation is practically the same throughout the various scholastic groups and that one would expect greater success from those who have had substantial achievement.

On examining the summer work data it is found that the successful men from the upper third, as reported by the schools, have not worked as much as the average of all successful men reported by them, although from industry the conclusion is the opposite. There is little difference, however, between the records.

Among the unsuccessful men in each of the two tables of unsuccessful men there is a complete divergence of distribution in those from industry and from the schools. The distribution between those complete lists of men and those for the upper third of the schools and in industry are somewhat the same.

In considering the data regarding earnings during college days it is seen that from the schools the reports show that most of the successful men from the complete list and from the upper third have earned none of their expenses, while the data from industry show that the largest number have earned some of their expenses. This latter finding is the same for the unsuccessful men in industry although school data in both tables show that the greatest number have earned a substantial amount of their expenses.

The industrial reports show that success or failure can not be judged by the earnings of the college student. The reports from the schools indicate that substantial student earning achievement is not indicative of later success.

Post Graduate Activities

The reported data regarding later activities of these men, although incomplete, are collected in the table below:

Post Graduate Activities of Successful Men

Further Study

	Industry	School
Systematic	26%	58%
General	52	10
None	22	32

Civic Activity

	Industry	School
Substantial	19%	22%
Some	29	22
None	52	56

These tables show distinctly that the successful men study after graduation. Over two-thirds of those reporting are carrying on some study and many of these are doing systematic work.

A little less than one-half of these men find time to do community work.

Conclusions

The data studied have shown no marked kind of achievement by a student by which future executive success can be predicted. There are some indicators which may be of value. They are as follows:

1st. Scholastic Standing:

In general, high standing indicates future success in the ratio of about three out of four cases, and low standing means failure in about three out of four cases.

2d. Opinion of Faculty:

The opinion of the faculty regarding success or failure was shown correct in three out of four cases.

Campus Activities, College Earnings and Summer Work do not seem to furnish information regarding future success.

The records in these different achievements of the men in the complete upper third seem to distribute among the different classes of activities in about the same way as is shown by the records of all men of the two general classes. This indicates that the distribution is the natural one among the records used and is not peculiar to the man of particular mental attainment.

The records show that most successful men continue to study after graduation and about one-half of them are interested in community affairs.

The committee was asked to state if native executive aptitude could be identified with a reliability of say 75 per cent in senior students at time of graduation, to what extent would such knowledge be definitely usable under the present personnel methods or a possible revision of personnel methods.

It is the opinion of the committee that scholastic standing is the factor which has almost this degree of reliability and that present or future personnel methods have been based on this. The facts that men of high standing have failed to make good in after life and that the low stand man may and does at times develop later into a successful man, furnish the justification for including him in the list of selected seniors if the personal impression made by such a man is satisfactory to the personnel officer. The 25 per cent

element of doubt would still make it necessary for the personnel officer to give the man of attractive personality in the lower scholastic rank a chance to make good.

The committee believes that one element or even two or three elements are not sufficient on which to base a definite selection.

Respectfully submitted,

ARTHUR M. GREENE, JR., *Chairman*

REPORT OF COMMITTEE ON ENGINEERING RESEARCH AT THE COLLEGES AND UNIVERSITIES OF NORTH AMERICA

BY R. A. SEATON, *Chairman*

Supplement to February, 1931,
JOURNAL OF ENGINEERING EDUCATION

CO-OPERATIVE ENGINEERING EDUCATION IN THE SOUTHEAST

Although the severe economic depression has made its inroads on all kinds of business the co-operative students at Georgia Tech and at other institutions in this section are surviving with even greater possibilities. Such engineering concerns as the Southeastern Power, the railroad shops, the steel companies, the Southern Bell, the Westinghouse, the General Electric, and many other corporations of like nature are maintaining pretty nearly their full quotas; this indication discloses the real value of the Co-operative Plan to the engineering field.

At present when employment is scarce; when the manager of employment tells the college coordinator or the solicitor for student labor that only men of families striving for mere existence will be used on work, the real problem of modern technology is at hand. Social questions and problems are at battle against the economic and mechanical forces of industries and nature. Will the modern entrepreneur show himself a benefactor to the unemployed who may be totally unfitted for the technical work or will he resort merely to production for profits? Perhaps for a definite, short time a restricted class of people without work will be used regardless of their skill or ability, but after all in this machine age, time of mass production, period of high-pressure selling and ruthless competition, this decade of colossal mergers, the business manager will find need and urgent need for the alert co-operative students who can quickly adjust themselves to the exigencies of the moment, to the latest mechanical contrivances which are necessary for the tense competition in this civilization. Only a few who are trained in modern technology can be used profitably in the industries of today. Thus the reaction to continue the services of co-operative employes notwithstanding the depression is already noticeable among the captains of industries in this Southeastern section.

The co-operative student who has integrity, fortitude, ingenuity, and pride in achievement as well as technical ability is in great demand especially during these hours of unremitting sources of strain and worry. In earlier days the rigors of the climate, the maladies of contagious disease, the savage and pirate marauders were dreaded and feared, but today we live in apprehension of local, national and international riots brought about through economic maladjustment. No longer does one view the economic distress as

a personal problem; he contents himself by attributing the trouble to some general cause as the tariff, overproduction, the Patrician money lords, etc. People now seem to have lost all orientation of themselves. The student who has studied political economy, literature, and history along with the technical engineering subjects is a great help both in a technical and cultural way to the industry especially now when every business concern or manufacturing plant has so much discontent and unhappiness among its laboring classes and even among its office forces. College students are refreshing and philosophically helpful to the masses of employes or wouldbe employes who are becoming distrustful and alarmingly pessimistic toward our highly developed civilized world.

Although the co-operative student may think that he is having the most difficult year of all years to survive, he is perhaps learning more now than ever before from the outside contact with his practice work. A practical application in sociology, or economics, or ethics, or psychology, or in any of the humanities can be experienced in almost any industrial plant of today. The industrialist also now more than ever before realizes the importance of giving employment to co-operative students, who will not be such easy victims to the ravages of nervous and mental disease caused by the strain of sociological unrest and who will not wonder because the individuality which formerly meant so much to a successful organization is now submerged with the predominance of mass production. Thus the co-operative students, because of their particular educational training, are in demand in the Southeast, and should be in demand throughout the industrial world.

J. E. McDaniel.

THE T-SQUARE PAGE

FREDERIC G. HIGBEE, *Editor*

SECTIONAL VIEWS: THE ENGINEERING DRAWING SUMMER SCHOOL

"... The whole status of engineering drawing would be raised materially if the instructors in the other courses in the curriculum would realize that they would be even more highly credited for the teaching they were doing in applied science and engineering work, if they too would insist on neat representation whenever the graphical language is used, just as the employer insists and financially encourages neatness and accuracy of expression on the part of the engineering graduate whom he employs."

DEAN F. DER. FURMAN.

"Drawing is not a side line to be carried by an instructor of physics or chemistry. To delegate its direction to the inexperienced or immature is a crime against the student and a detriment to the engineering profession. It should be taught by a specialist trained in knowledge and skill, with a background of drawing board experience and a teaching instinct, who appreciates both the importance and the difficulty of his work and accepts with an earnest enthusiasm the responsibility of training the young minds intrusted to him in a subject of such indispensable value that without it modern engineering could not exist."

PROF. THOMAS E. FRENCH.

"... The development of intelligence in the student is far more subtle and excites little or no interest in him. It is characteristic of student psychology that he is very keen for information and for experience that promises to be useful to him after graduation, but he is very indifferent to the cultural value of any study, especially if he is convinced that it is non-essential. He believes in education *theoretically*, but he prefers to be stuffed with information."

PROF. WM. GRISWOLD SMITH.

"An atmosphere should be created in the drawing department that will encourage every member of the staff to attach himself to a national organization or association with others that will permit him to present his opinions and suggestions in such a way that they will receive the widest attention and have the greatest influence on those whom it is desirable he should know and be known by. The organization under whose auspices we are now assembled has done much in the past and will do more in the future to raise the status of the engineering teacher and to make his voice effective in the councils of educational leaders. The drawing teacher must not lag in doing his part."

PROF. H. H. JORDAN.

COLLEGE NOTES

Massachusetts Institute of Technology.—Construction has been started on a new building which will house the research sections of Physics and Chemistry. The structure will be 300 ft. by 60 ft. and will consist of four floors and a basement.

As spectroscopy is becoming more and more important in the field of atomic structure a special vibrationless, constant-temperature laboratory will be built for housing the spectroscopic equipment. The two floors of this building will be specially supported separate from walls and roof, and the whole building will be so well insulated that if the outside temperature were suddenly to change one hundred degrees it would take the interior about a month to change one degree.

It is also planned to construct a cryrogenic laboratory for research at extremely low temperatures. This laboratory will contain plants for the manufacture of liquid nitrogen, hydrogen and helium in quantity.

The first play presented this year by the Tech Dramashop was Gogol's ''Marriage.'' This is a Russian play which depicts the customs and foibles of the Russian bourgeois class about the middle of last century. Although this type of play was unfamiliar to most of the audience it met with an enthusiastic reception.

BOOK REVIEW

Electric Circuit Analysis. By MICHEL G. MALTI, of Cornell University. Published by John Wiley & Sons. Price $4.50.

This book contains nineteen chapters, treating the subject of alternating current circuit analysis from a mathematical viewpoint. There are 389 pages. The appendix includes theorems and their proofs together with mathematical and physical tables.

At the end of each chapter many problems are recorded, which in the writer's opinion tends to make such a book as this more *''usable''* for the large majority of students who get principles best by means of some drill.

The author has undertaken to give some physical concepts preceding his purely mathematical treatments, but the problems seem to emphasize the importance of knowing mathematics.

The book should find its largest application with students who are majoring in Electrical Engineering. Teachers who prefer

mathematical treatments of the simplest fundamentals will probably adopt this book for their alternating current circuit courses. After the first three chapters have been *mastered,* the remaining sixteen chapters can be taken up in almost any order one might wish to consider them.

R. C. G.

EMPLOYMENT SERVICE

TO THE MEMBERS OF THE SOCIETY:

In order that the Society may be of further assistance to you, we are compiling a list of vacancies which will be open in the engineering schools of the United States and Canada next year.

If you desire to make a change in your position, please advise us the type of position you wish; the section of the country in which you prefer to live; the salary expected. We should also have full information concerning your qualifications so that we may refer these to the institution seeking a man of your ability.

All information received in response to this notice will be kept confidential and sent only to institutions where there is an opening which will benefit you.

This information should be in our hands at once as appointments for next year will be made within the next two months.

If you have vacancies in your department, please list them with us.

There is no fee attached to the above service.

Very truly yours,

F. L. BISHOP,
Secretary.

The **South Dakota Section** held the fourth annual meeting at the Hotel Lincoln, Watertown, S. D., January 8, 1931. Nineteen members and visitors were in attendance.

The morning session began with a short business meeting, after which the president of the Section, Dean L. E. Akeley of the University of South Dakota, gave his presidential address, "Some Liberalizing Objectives in Engineering Education." This address was followed by two papers, "Inspection Trips for Engineering Students," by Prof. H. S. Carter of South Dakota State College and Prof. H. E. Brookman of the University of South Dakota. All three papers were quite widely discussed.

"The Teaching of High School Mathematics," by Dean H. M. Crothers, South Dakota State College, was the first paper presented at the afternoon session. This paper created considerable interest and was well discussed by the members of the Section and visitors from the local and neighboring town high school faculties.

The last paper on the program was presented by Mr. H. B. Porter, Plant Extension Engineer, Northwestern Bell Telephone Co., Omaha, Nebraska. The paper was entitled "The Application of Engineering to Present Day Problems." This paper was filled with optimistic, common sense philosophy applicable to engineering student, engineering teacher and engineering graduate.

In a short business session the following officers were elected for the coming year:

Prof. H. S. Carter, President, South Dakota State College.
Prof. E. E. Clark, Vice-President, South Dakota School of Mines.
Prof. H. E. Brookman, Secretary-Treasurer, University of South Dakota.

E. E. CLARK,
Secretary-Treasurer.

TECHNICAL INSTITUTE EDUCATION IN AMERICA *

IN THE UNITED STATES

By ROBERT H. SPAHR

General Motors Institute of Technology

Three groups of resident institutions in the United States are at present operating in the post-secondary age and preparation levels of engineering education—the four-year colleges, the technical institutes, and the junior colleges. The four-year engineering colleges number close to 150, the technical institutes between 30 and 40, and the junior colleges, offering engineering or pre-engineering courses, approximately 100.

At the present time, practically all of the junior college programs are intended primarily to prepare for the third and fourth years of the four-year college; in contrast, the technical institute programs invariably are intended to train for rather immediate employment in responsible technical and supervisory positions. Both groups of schools deal almost wholly with briefer technical courses, yet these courses differ in type as well as in objective.

One recognizes in the technical institute area three rather distinct types of curricula: (1) engineering courses which parallel the college courses but in briefer, more direct, intensive, and practical forms; (2) courses in the technology of specific industries; and (3), courses preparing for particular technical functions.

These technical institute courses are more directly technical than are those of the junior and four-year engineering colleges, yet they include a substantial treatment of the underlying and related sciences, and usually some work in English and economics. The practice actually of *doing to learn* is an important characteristic of the instruction; a considerable portion of the student's time in school is devoted to practice in laboratories, shops, drawing, and design. Students are admitted to these courses primarily on evidence of their capacity, interest, and in some instances future employability rather than on formal scholastic credentials.

These courses are usually devised to meet the needs of those having a fairly settled vocational aim, those who for financial reasons cannot spend four years or more in preparation for remunerative employment, and those of mature age who from practical experience have discovered their technical bents and have realized the need for

* Presented at the Annual Meeting of the Society for the Promotion of Engineering Education, Montreal, June 28, 1930.

systematic technical education; further, these courses point to the higher practical pursuits of industry rather than to the specialized intellectual functions of research and analytical design.

Certain historical influences probably caused the colleges to outgrow and overshadow the technical institutes in America, the reverse of the experience abroad; but while outdistanced in numbers, several of the technical institutes in America are notably successful as measured by results.

By virtue of the characteristics of technical institute education and its close relation to industry, the major development to date has come in that part of the United States east of the Mississippi and north of the Ohio and Potomac rivers. At this time there appears to be going on a definite and positive development of technical institute education in the newer industrial areas, notably California. On the other hand, the major development of the junior colleges has occurred in the south, central west, and west, with relatively few in the northeast section of the country.

About 57 per cent of the present institutes are operated privately; slightly more than half of these have endowments which range in amounts from those able to care for a large part of the institutional expense to those whose incomes assist little in operating the school. Slightly less than half of the private institutes have no endowments, and these operate on a self-sustaining basis.

Of the present institutes 33 per cent operate under public auspices, either state or city, and 10 per cent enjoy both private and public support. By way of comparison, in 1923, private junior colleges outnumbered publicly supported junior colleges about two to one.

An analysis of the programs of thirty of the institutes shows that the major part of the technical institute instruction of sixteen is conducted as regular full-time day instruction, the work of six as evening instruction, of six as extension or correspondence instruction, of two by the coöperative method.

The lengths of the courses, for the satisfactory completion of which diplomas or certificates are granted, vary from one to three years measured by full-time day instruction; no course less than one year in length measured by this standard was considered in the S. P. E. E. technical institute study. The courses average approximately two years.

The institutes which operate on the full-time day basis run about thirty-six weeks per year, and the students average thirty-three clock hours per week with instructors.

The curricula in a large number of the institutes appear to have been influenced largely by the objectives in the minds of the founders, and in others by the influence and personality of the present

administrations. In some instances there are distinct indications that the objectives of the founders have been radically changed by later administrations; indeed, in some instances this may have been through necessity.

The one question raised most frequently during the study had to do with the content of the curriculum. That is, whether the right subject matter, in the correct proportional amounts, extending over proper periods of time, for maximum effectiveness, is being taught. These items are of far greater significance in the building of a shorter terminal-point curriculum of one or two years in length than in a longer curriculum of four years. In the former, time very definitely dominates the situation. There is only time available to give instruction in essentials thought to be necessary to attain certain predetermined objectives.

The shorter the course the more rigid must be the schedule of studies. There is little opportunity for the student to substitute subjects or choose electives. The curriculum offered is expected to be the one best and quickest path to a particular objective; its construction requires experience and skill which the student necessarily lacks. The terminal character of these courses is another reason why it is necessary to be exacting, inclusive, and careful in the laying out of the curriculum. As the course becomes more definite in purpose or objectively vocational, the more inflexible must be the curriculum.

A few believe that they have solved these curriculum questions in a manner satisfactory to themselves through systematic study and experimentation; but a solution in one case may not answer in all cases. In this area of education, for every school which has solved its curriculum problems satisfactorily to all concerned there are five which have not. Several institutions in this area have been eminently successful in attaining desired objectives, the majority have reached a fair degree of success, while a few are groping aimlessly. Many of the uncertainties which exist may be attributed in part to the relatively brief period in which most of these institutions have operated; there were few graduated prior to 1900, the growth having occurred largely since the war period. The junior colleges because of their primary objectives and rapid development have adopted the curriculum of the first two years of the college or university; however, there is, at this time, a definite move on foot to study their curricula from the standpoint of the needs.

Beginnings have been made in more scientifically planning and building curricula. Several experiments in this direction are now in progress which deserve watching. One of these is in the technical institute area. This technical institute is revising its curricula through the aid of so-called job analysis. It is not more

than reasonable to expect that a school may more effectively and efficiently strike at its goal if it knows the duties and responsibilities which the graduates meet in actual practice.

No universal title applies to the administrative heads of these institutes as is the general practice in colleges; those in common use are president, director, and principal. The administrations, in general, exert more definite and positive control over the workings of the school than do the administrations of the colleges and universities. The control probably parallels more closely the business organization than it does college procedure. This makes it possible to make changes more easily and obtain more direct action when and where needed. It appeared quite clear that the most successful schools were those which happened to have the highest degree of centralized control.

Professorial titles are practically never used in the institutions whose major work lies in the technical institute area. They have supervisors and heads of departments, but few other designations. Thus they probably pay salaries in legal tender instead of by titles.

Costs, and particularly comparative costs, are difficult to obtain, and at best only general conclusions are possible.

	Minimum	Average	Maximum
5 Technical Institutes (1928–29)	$275	$411	$450
9 Four-Year Engineering Colleges (1925–26)	$264	$571	$712

The average estimated cost per student per year, excluding interest on plant, in 1928–29 for five technical institutes was $411, while this same cost for nine four-year engineering colleges in 1925–26 was estimated to be $571, which is 39 per cent higher than the average and about 29 per cent higher than the maximum estimate of the technical institute cost. However, the minimum technical institute cost slightly exceeds the minimum four-year engineering college cost. In this connection it is interesting to note that the maximum estimated cost per student per year, excluding interest on plant, from fifteen junior colleges in 1922–23 is less than the minimum for either the technical institutes or the four-year engineering colleges just cited.

The indications are that technical institute education is costing at present slightly less than four-year engineering college education, yet if done well there is reason to believe that it will cost practically as much as engineering college education. In general, if funds are inadequate to run four-year engineering colleges, they

are, likewise, inadequate to operate technical institutes, though exceptions may exist.

An analysis of the faculties shows that about 25 per cent of the members of the technical institute staffs have no degrees compared to about 14 per cent for the four-year engineering colleges. The majority of the members without degrees in both technical institutes and colleges are found in the shops, or teaching other practical and applied subjects. In one of the schools, recognized as one of the most efficient in the technical institute or any other area of education, 86 per cent of the faculty have no degrees, but all are graduates of the institution itself.

Every teacher in the study reported has taken some course beyond high school, or of an adult nature; 71 per cent have had four or more years beyond high school; 18 per cent have had graduate courses ranging from one to four years. In nearly 100 per cent of the cases, they have had practical experience ranging from one to thirty-five years before being employed as members of the faculties.

Of the faculty members, 62 per cent hold membership in professional societies; 85 per cent of the members of one faculty hold membership in one or more professional societies. About 15 per cent of all faculty members in this area of education are members of the S. P. E. E.

In general, the clock hours of teaching per week are larger than in the the four-year engineering schools and much above those in the liberal arts colleges, and the number of students per section for class room is very frequently 35 to 40.

Where both day and evening classes are held, teachers commonly have part of their work in each division. In these cases they either receive extra compensation or have their hours of evening work counted in their weekly schedules.

The amount of original productive work is considerable; more than 25 per cent of the teachers have publications of some form to their credit, and 20 per cent have made one or more inventions. Many on the faculties of the full-time schools maintain a considerable amount of consulting practice. The largest case noted was $10,000 a year from consulting fees.

The median age of the teachers is close to 35, and the median period of teaching experience is between seven and eight years.

Data covering three full-time staffs exemplifying the best standards cover a range of individual salaries from $1,900 to $6,000 a year with medians of $3,600, $3,100, and $3,000 respectively.

The rates for evening school teaching are seldom proportional to these rates. But one individual, teaching in the evening, reported a normal salary beyond $5,000 and the modal group lies between

$2,500 and $3,500. It appears that much evening teaching is plainly a means of earning extra income adopted by fairly low salaried men in practice, though some notably successful teachers are found in this group. In class visitations, by far the best teaching was observed in the full-time day classes, and by far the poorest, with one exception, was observed in extension and evening teaching.

Considering all of the schools in this area of education, nearly one half of the alumni and present students had practical experience in the field of work for which they expected to prepare themselves. Considerably more had experience in some form of employment. The average age of technical institute students at graduation is not far from the average age of four-year college students at graduation; this indicates at least, an interval of employment of from one to three years between high school and entrance to the technical institute. These factors have undoubtedly assisted them in forming rather definite objectives. In one particular study of 629 alumni it was found that at the time of entering the institutes 68 per cent had a specific field of work in mind for which they expected to prepare. When asked why they chose to attend these institutes, when on the whole about three out of four had adequate preparation to enter four-year colleges, eighteen reasons were advanced; the dominant one was "believing personally in the results of this type of education."

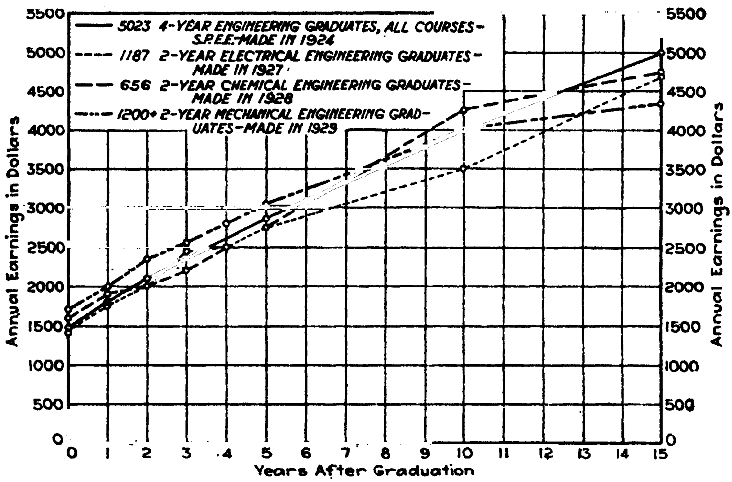
It will be interesting to note that advertisements in current literature, in general, did not influence the decisions of many attending these schools. It is not uncommon for institutions in all areas of education to advertise their courses. Comments from alumni reflected no criticism of the amount of advertising but did reflect criticism of some particular types. It is gratifying that the literature and advertisements of the institutions falling within the scope of our study, with but few exceptions, were found to follow facts closely, and only a very few might have been termed misleading. Here it may be well to state that the chief offenders in misleading and probably non-factual publicity happened to fall within other areas of education.

The reputation of the school influenced 75 per cent of the alumni; this has increased to 85 per cent for the present students.

Of the graduates of five of the institutes, 53 per cent paid more than one-half of their expenses, and 42 per cent paid more than three-fourths of their total expenses. This may indicate that lack of means for a longer course played a part in their choice.

It was found that, leaving out of account all purely personal considerations, the alumni have not found the absence of a college degree a tangible handicap in obtaining employment, advancement, and recognition by professional and business organizations.

The earning power of the graduates of the more efficient technical institutes parallels quite closely that of the engineering college graduates of the same maturity. It is surprising that there is no greater difference between the median earnings of the one, two, and four-year graduates. The earnings in after years are certainly not in direct proportion to the lengths of the courses. The graduates appear to be in considerable demand. For example, one school has a standing order from a large concern for five graduates each year, who are accepted without interview, on the basis of the school's recommendation.



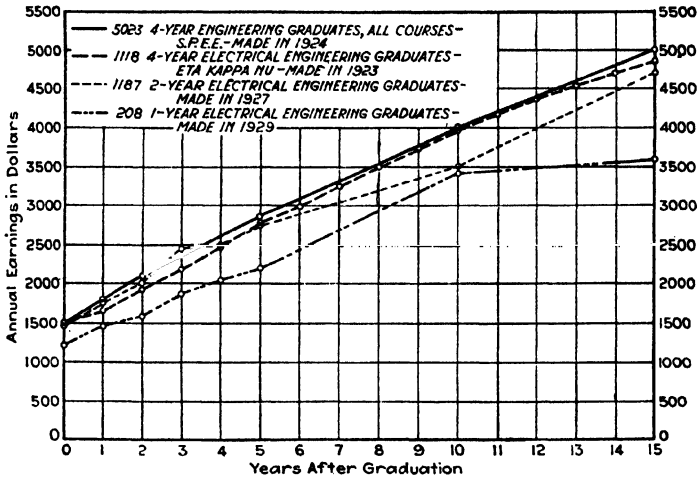
Median Earnings

A valuable index as to the effectiveness of a particular type of education is found in the reactions of its graduates. Graduates from twenty-five years ago to the present are fairly unanimous that they would go to the same type of school and take the same type of course if they had to do it over again.

Of all the evidence gathered, that which deals with the requirements of industry is probably the most conclusive.

An attempt was made to determine the needs for technically trained men in business and industry. Employers were asked to study and analyze their needs in terms of ratios of technical institute graduates to four-year engineering college graduates. It is significant, almost incredible, to find four ratios, resulting from four studies conducted at different periods under different circumstances in different industries even in different parts of the coun-

try, so nearly alike in size respectively 2.8 to 1, 2.7 to 1, 2.7 to 1, and 2.6 to 1. This means that industry says that to operate efficiently, it should have 2.7 technical institute graduates to 1 four-year college graduate. Roughly, the manufacturing industry has indicated that from 6 to 8.3 per cent of its total employees should be technical institute graduates; that from 2.2 to 3 per cent of the total employees should be four-year college graduates; and, that about 15 per cent should be trained in elementary manual and industrial courses.



Median Earnings

In order to check the results obtained, an inquiry was made of fifteen representative companies, located in eleven states, which were known to have experience with both technical institute and college graduates. These companies were asked whether from their experience they felt that there was an area of terminal education, intermediate in duration between vocational and trade schools on the one hand and engineering colleges on the other, needing to be encouraged and developed in America. The replies were unanimous in the affirmative. The relative importance of the aims of technical institute training, as indicated by the composite replies of these fifteen companies, is as follows:

1. To qualify men for supervisory positions in operating departments.
2. To qualify men for technical services such as drafting, designing, testing, inspection.

3. To qualify men for commercial positions relating to the sale of technical products and services.

A significant fact which cannot escape attention is that four-year college trained men do not enter the production function of industry in large numbers. In contrast, the largest numbers of technical institute men enter production. Industry contends that there is not only a vital need for technically trained men in production but that there are excellent opportunities as well.

Distribution by Functions of Graduates of Colleges and of Technical Institute Courses

Groups of Positions, or Functions	15,094 College Men in Technical and Supervisory Positions	1,398 Shorter Course—Technical Institute Men (Electrical) in Technical and Supervisory Positions	325 Shorter Course—Technical Institute Men (Textile) in Technical and Supervisory Positions
General Officers	9.9%	11.1%	22.5%
Engineering and Technical	33.0%	26.0%	20.0%
Production	9.0% (Lowest)	33.0% (Highest)	24.3% (Highest)
Sales and Advertising	38.1%	6.1%	10.1%
Miscellaneous	10.0%	23.8%	23.1%
	100.0%	100.0%	100.0%

There are, at present, approximately one-fiftieth as many technical institute men in manufacture as the employers say they should have. An output of from 15,000 to 20,000 technical institute men could probably be absorbed annually in manufacture alone. Less comprehensive estimates from the public utility and transportation industries indicate demands in proportion.

There are fields, such as engineering, which the technical institutes, or shorter course institutions, may divide with the four-year engineering colleges in fairly equal proportion. However, in order to serve more completely the needs and create for themselves a permanent place in the technical education program, these institutions will need to serve a group of purposes quite distinct from those of the four-year engineering colleges.

The following are possibilities for development in technical institute education:

1. Technical education, not trade training, for particular industries or functions rather than professions, such as textile manufacturing, coal mining, printing, power plant management, and production engineering. There is a growing need for a type of technical education for foremen, inspectors, maintenance men, and superintendents in production and plant departments.

2. Technical education for numerous semi-professional positions, for contracting and construction, for selling, installing, servicing technical appliances, and for proprietorship.

3. Technical education for young men who have been employed and wish training for immediate ends. The four-year college course does not appear as suitable for such men as does the technical institute course.

4. Technical education adapted to young men with limited time and money, with generally practical and mechanical tastes, or with preparatory education lacking some of the more academic subjects, and for superior graduates of vocational courses and continuation and trade schools.

These four fields indicated, together with others, are largely unprovided for in the present educational system. This is a vast field of service, mainly in the post-secondary age and preparation levels of education, waiting to be developed.

The technical institute courses are well suited to meet these needs. The junior college courses are not now well suited, but might be made more so by changing their curricula, where conditions justify, to prepare men for immediate and effective employment rather than for more advanced instruction; provided also, that adequate equipment, together with practical and qualified teaching personnel are available. It must not be forgotten that it is far simpler, easier, and less expensive to give the usual junior college engineering work than the technical institute type.

The coöperative plan, alternating periods in school and at work, which is probably of limited applicability at secondary age levels, appears to be well adapted to the aims and work of the technical institutes. It eases the economic burden on student and school alike and affords a highly desirable trial of aptitude and orientation to industry, without necessitating a break in the continuity of education.

There is the same place in the technical institute area of education for the independent endowed institute as for the endowed college in its field. Independence of public control enables the institution to experiment, work on a selective plan, and set standards with ideals of special excellence rather than of the broadest possible public service.

It appears that no field or area of education in America offers the same possibilities for development and service which the technical institute area does. People with money who have a desire to endow educational institutions could probably find no more effective means of real worthwhile service than this area of education.

It seems clear, however, that the actual needs and potential de-

mands are so great that they may be met only by public institutions with a definite place in state and city education system. European experience tends to support this position.

Associating a technical institute giving higher terminal courses with a technical high school has not yet been tried, so far as is known. It appears practical and might go far toward solving the problem of adequate development of technical education of this character over the country as a whole. Experience tends to discourage the operation of a technical institute course parallel with the four-year degree granting engineering course on the same campus, under the same administration, and under the same faculty. No experiment along this line has yet proved satisfactory.

There are at least half a dozen developments in this area of education being considered at this time, and in each case the speaker has advised that careful consideration be based upon the study of the facts, and has discouraged at all times the attempt to organize such an institution without adequate funds looking toward permanency. It seems quite clear that in order to develop as they deserve, more of these schools and courses in this area of education need to be organized around more specific and more clearly visualized aims.

Technical education, be it short or long course type, engineering or technological in character, is so important that it must have adequate representation in the formulating of educational policies whether they are city, state, or national.

Technical education is that upon which the motivating spirit of industry is built, and it teaches the principles by which industry progresses. Without successful and efficient industry America would be placed in an unfavorable position.

In the forthcoming S. P. E. E. report, Vol. II, a fuller discussion, illustrated by much interesting data, together with interpretations by the staff, will be found.

IN CANADA

By AUGUSTIN FRIGON

Director-General of Technical Education for the Province of Quebec

When I was invited to talk to you on institutes of less than college degree, I was given a very easy task, because although we have a good many technical high schools and trade schools in Canada, outside of the Province of Quebec there is only one institute of that type, and that is the Calgary Institute of Technology and Art. That Institute was founded in 1916, and last year it offered

courses in the following subjects, in order of importance as far as number of students enlisting: tractor engineering electrical engineering, dressmaking and millinery, farm mechanics, telegraphy, automatic electricity, drafting, machine shop, and industrial art. That Institute is, what you would call, I believe, a very high-grade trade school.

In Quebec, we have what I would classify as really genuine technical schools. In 1907, the Quebec Legislature passed a law providing for the creation of technical schools. A gentleman who had been one of the prominent men in technical education in France was engaged to organize these schools. He founded the Quebec, the Montreal and the Three-Rivers schools. Since then the Hull School has opened. These schools are owned and operated by the Provincial government and they receive a fixed amount each year from the city in which they are located. The Provincial government supplies whatever amount is necessary to keep the school going.

These schools offer a variety of courses. They have the standard evening classes. This year, in Montreal, we had 2,300 students enlisted in the evening classes. They have a two-year trade course, special courses for automobile mechanics, and others of that character. There is at the Montreal School a part-time apprenticeship course in typography. Their most important work however is a three-year course for "technicians," or in other words, a technical course. Students are admitted in that three-year course from the second year of high school, and they receive a general training in technology and shop practice. During their first year they spend about three quarters of their time in the classroom and the rest in the machine shop, the woodworking shop, the smithy and the foundry.

During the second and third years, half their time is spent in the classroom and laboratories, and the rest in the one shop in which they have chosen to specialize—the machine shop, the woodworking shop, the foundry, the smithy or the electric shop.

There is one characteristic of our schools which might interest you and that is that they are strictly bilingual. A boy has the privilege of studying either in French or English. All of our activities are double. We do not organize one course without providing for that course being given in the two languages. In Montreal, all instruction is given in French and in English, to different groups. In Quebec and Hull we have few English-speaking pupils. In those schools we may have no English class for a year or two, and then we may have to follow one or two pupils through their course with an English section. Every teacher must be able to give instruction in both English or French. Of course, we

try to give English teachers to English boys, and French teachers to French boys, but every professor or instructor must be prepared to step in and take the place of any colleague who might be away temporarily. You will understand that they constitute a problem in recruiting our personnel. We can easily find English teachers on this continent, but when it comes to getting a teacher who can talk both French and English, it is not as easy.

Another point about these schools is they are strictly for boys, and their curriculum is limited to what you might call the electromechanic art. We have no commercial and no home economic courses of any sort.

I told you my task would be very easy and here is why. Last year we prepared a moving picture which is supposed to illustrate very clearly the character of our technical course. We have taken one special problem, as you will see, and we follow the problem as it is studied by the students in their different classes and shops. I think if I show you this film it will tell you more about what we have in mind in our curriculum and methods than I could tell you in two hours talking. You will notice that this one problem is more particularly connected with the machine shop.

Showing of Film

Gentlemen, this film was not prepared to be shown to such a gathering as this. However, we have tried to show that we are trying to be very thorough in our work and to give our students a thorough instruction in science, technology, mathematics, and manual training. We have wonderful machine shops which are organized as industrial shops would be in any big industry. The school is open for inspection and by looking it over, you will have a good idea, I am sure, of what we do in this Province in technical education of less than college grade.

THE 1931 SESSIONS OF THE SUMMER SCHOOL FOR ENGINEERING TEACHERS

BY H. P. HAMMOND

Director of Summer Schools

The two sessions of the Summer School for Engineering Teachers for 1931 were announced in the December, 1930, number of the *Journal of Engineering Education*. Since that announcement the programs have been practically completed and the staffs recruited. The present article is written for the information of the members of the Society in general, and in particular for those who may plan to attend either of the sessions.

Session on Chemical Engineering. The session for teachers of chemical engineering will be held at the University of Michigan, Ann Arbor, Michigan, from June 23 to July 9, inclusive. It will be followed by a conference on chemical engineering education, held under the sponsorship of the American Institute of Chemical Engineers, at Ann Arbor, on July 10 and 11. A trip of inspection to industries of the Pittsburgh district, which will be optional for those in attendance, will be held on July 13 to 15, inclusive. During the stay in Pittsburgh, the headquarters of the group will be at the Mellon Institute of Industrial Research.

The program of the chemical engineering session is divided into four principal divisions, as follows:

1. The Teaching of Chemical Engineering and Allied Subjects
2. The Application of the Principles of Chemical Engineering in Industry
3. Laboratory Work in Chemical Engineering
4. Historical and Miscellaneous

Some idea of the nature of the various portions of the program can be secured from the following excerpts:

Wednesday, June 24

8:15 A.M.	The Place of the Teaching of the Unit Processes in a Chemical Engineering Curriculum. W. K. Lewis
10:00 A.M.	The Nitrogen Situation. H. A. Curtis.
1:30 P.M.	The Place of Laboratory Work in a Chemical Engineering Curriculum. W. L. Badger.
2:30 P.M.	Inspection of the Chemical Engineering Laboratories of the University of Michigan.

Thursday, June 25

8:15 A.M.	The Teaching of the Principles of Distillation. W. K. Lewis.
10:00 A.M.	Petroleum Refining. R. E. Wilson.
1:30 P.M.	Historical Development of Chemical Engineering. W. L. Badger.

Friday, June 26

8:15 A.M. The Teaching of Fluid Flow and Fluid Measurement. R. S. Tour.

10:00 A.M. Recent Development in Food Industries. L. V. Burton.

1:30 P.M. Discussion of Laboratory Experiments on Fluid Flow. H. L. Olin.

2:15 P.M. Discussion of Laboratory Experiments on Distillation. J. R. Withrow.

Saturday, June 27

8:15 A.M. Price Trends in the Chemical Industries. S. D. Kirkpatrick.

10:00 A.M. Teaching of Heat Flow (general, except radiation). J. C. Olson.

P.M. Recreation.

It will be noted that three divisions of the program are carried along in parallel: the teaching of the principles of chemical engineering; the organization and the teaching of laboratory work; and the applications of principles to industrial processes.

The program will be so arranged that those in attendance will secure not only general statements of the principles and methods of presentation, but will also have a complete and logically arranged set of representative problems of the principal chemical engineering processes with their solutions, which will be worked out and presented by members of the teaching staff.

As in past sessions of the Summer School, those in attendance will be supplied with complete sets of lecture outlines in mimeographed form, so that they will have at the end of the session a well arranged summary prepared by the ablest teachers in the field and by prominent practitioners.

While the staff of the session has not been completely recruited the following members can be announced:

A. H. White, University of Michigan, Local Director; W. L. McCabe, University of Michigan, Local Secretary.

Teachers of Chemical Engineering: A. H. White, W. L. Badger, and G. G. Brown, of the University of Michigan; W. K. Lewis and W. H. McAdams, Massachusetts Intitute of Technology; R. S. Tour, University of Cincinnati; H. L. Olin, State University of Iowa; J. R. Withrow and G. A. Bole, Ohio State University; J. C. Olsen, Polytechnic Institute of Brooklyn; Harry McCormack, Armour Institute of Technology; A. W. Hixson, Columbia University; G. H. Montillon, University of Minnesota; B. F. Dodge, Yale University; J. H. James, Carnegie Institute of Technology.

Practicing Engineers: H. A. Curtis, National Research Council; R. E. Wilson, Standard Oil Company of Indiana; L. V. Burton and S. D. Kirkpatrick, of McGraw-Hill Publishing Company; L. V. Redman, of the Balkelite Corporation, Bloomfield, N. J.; J. V. N. Dorr, of the Dorr Company, New York; Zay Jeffries, Aluminum Castings Company, Cleveland; C. O. Brown, Nitrogen Engineering

Corporation of New York; E. C. Sullivan, Corning Glass Works, Corning, N. Y.; and C. C. Furnas, Bureau of Mines Experiment Station, University of Minnesota.

As previously announced, the members of the chemical engineering session will be housed in Jordan Hall, a new dormitory of the University of Michigan, at a cost of approximately $17 per week.

In addition to the trip of inspection to industries in the Pittsburgh district, one entire day of the program has been set aside for a trip to the Ford Motor Company, at Detroit, at which plant there are many processes within the field of chemical engineering.

Session on Mathematics. The session for teachers of mathematics will be held at the University of Minnesota, Minneapolis, from August 24 to September 5, inclusive. The program is arranged in the following principal divisions:

1. General Principles of Teaching
2. Teaching of Mathematics to Engineering Students
3. Advanced Mathematics
4. Applications of Mathematics in Engineering Practice
5. Historical and Miscellaneous

Some idea of the specific nature of the program can be secured from the following illustrations:

Thursday, August 27

8:30 A.M. The Function of the Classroom Teacher. F. T. Spaulding.
10:15 A.M. Discussion—led by Louis O'Shaughnessy.
1:30 P.M. Representation of Functions by Series. Dunham Jackson.

Friday, August 28

8:30 A.M. Diagnosis of Student's Difficulties. F. T. Spaulding.
10:15 A.M. College Algebra—A Discussion of Course Content. W. E. Brooke.
1:30 P.M. College Algebra—Methods of Teaching. W. E. Brooke.

Saturday, August 29

8:30 A.M. Coördination of Mathematics with Related Engineering Subjects—A Symposium led by O. M. Leland.
10:15 A.M. Mathematics of Statistics. H. L. Rietz.

Monday, August 31

8:30 A.M. Analytic Geometry—Discussion of Course Content. W. J. Berry.
10:15 A.M. Analytic Geometry—Methods of Teaching. W. J. Berry.
1:30 P.M. History of Mathematics before the Seventeenth Century. R. C. Archibald.

Tuesday, Sept. 1

8:30 A.M. History of Mathematics after the Sixteenth Century. R. C. Archibald.
10:15 A.M. Differential Calculus—A Discussion of Course Content. E. V. Huntington.
1:30 P.M. Differential Calculus—Teaching the Nature of the Derivative. E. V. Huntington.
3:00 P.M. Differential Equations for Engineering Students—A Discussion of Course Content. Warren Weaver.

The staff of the mathematics session has been completely organized and is as follows:

O. M. Leland, University of Minnesota, Local Director; C. A. Herrick, University of Minnesota, Local Secretary.

Staff members: F. T. Spaulding and E. V. Huntington, Harvard University; E. R. Hedrick, University of California at Los Angeles; Louis O'Shaughnessy, Virginia Polytechnic Institute; S. P. Timoshenko, University of Michigan; Dunhan Jackson, W. E. Brooke and Dean M. E. Haggerty, University of Minnesota; H. L. Rietz, University of Iowa; W. J. Berry, Polytechnic Institute of Brooklyn; R. C. Archibald, Brown University; Warren Weaver and C. S. Slichter, University of Wisconsin; J. W. Young, Dartmouth College; T. C. Fry, Bell Telephone Laboratories; Charles N. Moore, University of Cincinnati; Leigh Page, Yale University.

The mathematics session will be followed immediately by the annual meetings of the American Mathematical Society and the Mathematical Association of America, which will also be held at the University of Minnesota beginning September 7. This arrangement has been made so that those attending the S. P. E. E. session who so desire may remain for the meetings of the mathematical societies.

As previously announced, the entire Summer School party will be housed in dormitories of the University of Minnesota at a cost not exceeding $35 for the two weeks.

The office of the Director of the Summer Schools is sending out at this time to presidents, deans, and heads of departments, announcements of the 1931 sessions. It is at this time that the largest number of applications to attend the sessions are received. It is advisable that those who expect to attend submit their applications promptly to the Director of Summer Schools, S. P. E. E., 99 Livingston Street, Brooklyn, N. Y.

METHOD OF TREATING THE SUBJECT OF PATTERN DESIGN AT THE UNIVERSITY OF ILLINOIS

By B. RUPERT HALL

Superintendent, Pattern Laboratory

Manufacturers and educators in the field of engineering are displaying considerable interest relative to just what training the engineering student should receive while in college. This inquiring attitude opens the way for constructive criticism of methods that have been and are now being employed in teaching the various manufacturing processes.

It is generally conceded that shop courses included in an engineering curricula are largely taught by stressing the manual phase of the work only. While this part of the work has its advantages in perfecting dexterity, it might be rightly claimed that too much time is consumed in reaching this goal that is not absolutely necessary in a professional way in actual engineering practice.

Time is at a premium in a four year engineering course and to meet this condition there is no manufacturing process subject that can be dispensed with without considerable detriment to the student in engineering. There are, however, methods that can be applied in presenting the various subjects that will greatly improve the work, thus allowing a greater field to be brought into consideration and an awakening of the visualizing and inventive qualities of the student thus rendering the work both entertaining and instructive.

A knowledge of the manufacturing processes and related sciences directly connected with any particular line of vocational work is exceedingly interesting and is of vital interest to the student in broadening his knowledge and tends to awaken a new sense of the subject as a whole. Fundamentals of manual operations are valuable but if treated as such alone are not at all interesting. Practical commercial problems requiring for solution a combination of the fundamentals of manual effort and associated sciences give the instructor interesting subjects not only for producing but also for class discussion.

A subject that is of considerable worth to the engineer when treated as applied in industry is that of Pattern Design, for either small or large production. In either case the design of the casting and arrangement of the pattern should be such as to facilitate the work to all concerned in which the making of the mold in the

foundry, also the machining of the piece in the machine department are involved. Further analysis of the part may show that the piece may be more economically produced in pressed steel necessitating the redesigning of the object. This naturally leads into the study of dies and presses, a subject of considerable interest and worth to the engineering student.

Having carefully considered the value of the training in actual manual work necessary to produce a pattern and the amount of time that will be consumed, if the student is required to produce with any degree of nicety, it appears that it would be expedient to sacrifice the making of the pattern and utilize the visualizing ability of students by substituting sketching and drawing to express ideas. Ability to do free hand sketching and instrument drawing are good assets to the engineer.

At the University of Illinois the work is carried on with the view of giving only that which may be of practical use in industry.

Pattern Design is the basis of our work and is demonstrated by the use of various types of patterns, core boxes and auxiliaries. Pattern Department management is treated with the thought of giving instruction in organizing such a department in a systematic manner to care for the large amount of detail usually involved.

We are using a text, "Pattern Design" that has been prepared solely for the purpose of giving the student only that which is important in the engineering profession in this phase of his work which assists greatly in carrying out this method of instruction.

It is often demonstrated in practice by drawings that have been submitted for a particular cast part that the designer has a very meagre conception of the processes involved in producing the piece. Faulty design, from a production standpoint, is a problem that is daily confronted in commerce causing considerable monetary loss. The designer being informed on the subject of manufacturing processes can greatly overcome this condition.

The work necessary to build a pattern skillfully requires considerable time. Manual work has its advantages when it is used to illustrate the different phases of patternmaking but the time of the engineering student can be used to better advantage by studying the design of patterns.

A Pattern Design is presented with the thought of familiarizing the student with the various ways and means of meeting the requirement with the least possible effort in producing the piece. By a careful study of these processes he is enabled to design a cast part in such a way as to facilitate the work to all concerned.

Casting design, pattern design and pattern construction are studied in a thoroughly practical way.

For pattern construction the student is given a problem that includes many different methods used in joinery by sketching the form of piece or pieces required to construct the pattern.

The next step is the study of the master pattern necessary to produce the metal working pattern, study also being given to the triple shrink pattern and its purpose explained.

The designing of metal pattern equipment is given extensive study including pattern plate, patterns, core boxes, core driers, core wire binding devices, core setting devices, etc.

Special problems are presented necessitating the designing of mechanical movements necessary in making a mold or a core thus reducing the work to a minimum.

There are many drawings of cast parts that may be simplified in design that present interesting and practical problems. A survey of blueprints or drawings used in industry will verify this statement and these furnish splendid problems as the student feels that his ingenuity is being put to a real practical test. Analyzing work of this character furnishes an opportunity for the student to display his initiative and develop his ingenuity and prove his aptitude for mechanical work.

The work is administered by supplying each student with a sheet of instructions explaining the necessary detail work. Problems of a very elementary nature but requiring careful study have been selected to introduce the student into the work. The ability of the student is quickly shown in devising ways and means of accomplishing desired results and a problem in keeping with his ability is given him for solution. In this method of instruction the alert student is not compelled to wait for those who are less fortunate.

The work is carried on entirely in the drafting room, free hand sketching and mechanical drawing, eliminating the manual work of constructing the patterns.

We find that the engineering students get four or five times the amount of technical knowledge and know more about general pattern work by this method of instruction than when they made the actual patterns in the laboratory.

A manual has been prepared treating on Pattern Design presenting the subject purely from the engineers' point of view.

THE COUNSELOR SYSTEM AT IOWA STATE COLLEGE

By LOWELL O. STEWART

Assistant Professor of Civil Engineering

Should a college treat its students with a sympathetic parental air, or should it assume that they are grown, sophisticated, and developed beyond the need of advice and counsel?

This has become a real problem. Prior to the World War colleges and universities were able to keep pace in faculty and physical equipment with the normal increase in enrollment. At present, however, the idea of universal education seems to be extending beyond the grammar and high school ages. The result is that each year finds larger numbers of young men and young women going on from high school to college or university with little or no knowledge or thought about the importance of the transition. Most of these young people are capable of carrying through a college course, but a very large number lack the purpose, aim, urge, and the "will to do" that is needed to set their intellects in motion. Naturally many become dissatisfied and unhappy, and as a result, make a sorry and discreditable showing. Others limp along through their studies content with a mere passing grade when they could, if their latent energies were set free and mobilized, become real leaders. Closely bound up with these are the numerous questions of finances, health, family conditions, sweethearts, and the like.

In the early days when enrollments were small it was possible for the college, through its deans and faculties, to maintain intimate and personal contact with each student. In fact, it was not uncommon to find at least one member of the faculty who knew every student on the campus. Those times have passed, but college authorities regret their passing and they are striving to set up simple, efficient, and economical machinery which will maintain that personal contact.

The plans, as well as the details, of this work have differed as the conditions and needs of individual institutions have differed. A few have set up comprehensive personnel systems with a trained personnel executive and competent assistants. At the other end of the scale are those who strove to obtain a little friendly contact with the students by assigning a few to each member of the faculty, who was to act as their adviser. Iowa State College used the latter scheme for several years until 1928 when President

Hughes planned and started the Counselor System which will be described in this paper.

Under the old system of advisers a small number of students, usually five or six, were assigned to each member of the faculty. These were kept within divisions so that an engineering student would go to a member of the engineering faculty, an agricultural student to a member of the agricultural faculty, a home economics student to a member of the home economics faculty, and so on. At the beginning of the fall quarter each member of the faculty would receive five or six pink cards, each of which gave the name, college address, and course of a student. The students received at about the same time similar individual cards telling them to call on Professor Smith, Professor Brown, or Professor Jones, at a certain room number in a certain building for help and advice.

Beyond this point the happenings depended upon chance, more or less. The faculty were busy and the students were shy. A young man might feel that he had done his part if he called and found the Professor's office locked, or the Professor might receive no reply to his request for an interview because the address was wrong. The result was that many of the students never did see their advisers while others made only a casual contact. There were a number, of course, who received much good from their more intimate associations with members of the faculty.

On the whole, the scheme was not a success. The reasons for its failure lay, not so much with the individuals, as with the principle. Several objections may be cited:

1. Many of these involuntary advisers were not qualified for and disliked such work.
2. The advisers had no administrative authority. They could report and recommend.
3. There seemed to be no particular aim or purpose in the interviews, beyond making out a time budget.
4. There was no checkup to see that the interviews were made.
5. There was no uniformity in the procedure or the requirements of the various advisers.

That scheme had failed to accomplish as much as had been hoped and the time was ripe for the counselor system, which President Hughes set up in 1928.

The people who became counselors were chosen because of their ability as teachers and their sympathetic attitude toward students. They became a part of the administrative system of the Junior College and were virtually deans over their respective groups of students. As such their word was very nearly final in all cases of policy, discipline, and the like, for the Dean of the Junior College,

Miss Roberts, held to the policy that the counselors should use their judgment and make decisions wherever possible.

Thirteen counselors were chosen in 1928. There were three from Agriculture, four from Engineering, three from Home Economics, two from Industrial Science, and one from Veterinary Medicine. Each of these counselors had charge of one hundred and fifty, or fewer, new students. In 1929 he continued in charge of his students who returned for the second year and added a new group of freshmen. Increased numbers made it necessary that a counselor be added in Engineering and in Home Economics so that in 1929 the number of students per counselor stood between one hundred fifty and two hundred.

Each counselor gave ten hours a week (in 1929, this became twelve hours) of scheduled time to the work. One of these hours was set aside for conferences with the Junior Dean or with other administrative officers. He spends his conference hours at individual desks in rooms arranged for his exclusive use. The counselors of a division have a common room, but conference hours are planned so that no more than two counselors will be in the room at one time, the thought being that the students will feel freer and more at ease if they have semi-privacy.

At the beginning of each quarter the students' class cards are marked with his counselor's name and the time at which the latter will be free to see him. The students are distributed as uniformly as possible amongst the counselor's scheduled hours to avoid unnecessary congestion. The student may, if he wishes, call on his counsel every week at his designated hour, and he may make special appointments. The essential point here is that there is an hour when the student may be sure that he will find his counselor. Naturally every man does not come in each week—if he did, a counselor could not possibly take care of two hundred men per week if he gave only eleven hours for that purpose. As a matter of fact the counselors do find it necessary to give additional time. Some men see their counselors often, sometimes to visit. Others come only when they have matters of importance, say three or four times during the quarter.

What do the counselor and the students talk about? Let us take them in order. All freshmen are required to see their counselor during the first two weeks of the fall quarter for the purpose of making a study budget. These study budgets are discussed at group meetings during Freshmen Week so that the student is familiar with the general idea. Every hour of the five and one-half day working week is allotted for study, classes, work, recreation, sleep, or other necessity, and so designated on the diagram.

Some of the students accept this as it is given, seriously; others feel that such a thing is beneath their notice as college students. However, at the end of the first six weeks all admit that it is needed.

After the completion of the time budgets, time is available for talking over special problems. The counselor now has time to look over the student's high school record and the results of the college psychological tests. Perhaps the individual snapshots are ready for his study. This must be done "between times" for there are many questions. This man is wondering whether he should study General instead of Civil Engineering; another has a limited amount of money and wishes to know whether he should borrow money or drop out of college for a while to earn some; another is having trouble with English and thinks that a tutor might help. At these interviews the counselor jots down notes about the man's appearance, habits, characteristics, and other important points that may be useful. Later he condenses and transfers these to regular personnel interview cards.

Progress reports, called mid-term grades, on each student's work are furnished the counselors through the Junior Dean's Office at the end of the first five weeks of every quarter. As soon as these grades are tabulated interviews are arranged promptly with every student who is making unsatisfactory progress. At that time the discussion is very frank regarding reasons for the poor showing. If the schedule is too heavy some is dropped; if the man has been lazy he is reminded of his obligation to make good; if he has been ill he is sent to the hospital for a special examination. Frequently, the student is asked to report his progress each week, which the counselor verifies by conferences with the boy's instructor.

During the last weeks of the quarter the counselor and student plan the latter's schedule for the succeeding quarter. For those who are making regular progress this is a simple and perfunctory procedure. A very large number soon become irregular because of entrance deficiencies, failures, lightened schedules for work or illness, and others. Each of these is a special problem. Some are making a poor scholastic record and are urged and required to carry a lightened schedule. Those who are earning a part of their expenses while in college are a problem for they, as a rule, wish to carry heavy schedules and do a large amount of work. All of this may be done after a fashion by a stenographer, but it can be done in a far more satisfactory manner by one who knows the students and the "ins and outs" of the course of study that he is following.

After the close of the quarter the Scholarship Committee reviews the records of those whose work seems unsatisfactory. At that time each counselor submits his list of names with all of the

data that he can assemble. He builds his case upon the opinions of other instructors as well as upon the observations that he has been making throughout the quarter. These opinions are returned on special cards that are sent to each instructor from the Junior Dean's Office.

The counselor appears before the Scholarship Committee in the role of a technical adviser. He sums up the results of all of his observations and, frequently, recommends the action which he thinks desirable. His intimate knowledge of the conditions that are influencing the student's progress makes him an invaluable aid during such deliberations.

A large portion of the counselor's time must be devoted to those who are making poor or slow progress. One of the most fascinating fields, however, includes those capable students who are working, palpably, below their ability. One learns from a study of such cases that the problem of education is complex and individual, and that a line of approach which is effective with one student may be useless with another.

The Counselor System is still new, but benefits and accomplishments seem to be emerging.

1. Misunderstandings between students and instructors are arising continually. While relatively small in themselves, they frequently lead to unhappy results. The students are prompt in bringing such matters to their counselor's attention. He is in a position to set things right in a short time.
2. In a like manner it has set up a general cleaning house to which any instructor can send information about students, which will receive prompt and sympathetic attention.
3. It is directing the attention of students to the need for a proper balance between work and play by helping them to budget their time.
4. It has helped men to find the course for which they are best fitted.
5. An attempt is being made to set right those capable students who are making poor records.
6. It has raised the percentage of good students who are retained in college and has hastened the withdrawal of those who are not of college caliber.
7. The counselor, having an intimate understanding of the work of the Senior College, has established better co-ordination between it and the Junior College.

THE "BOARD OF INQUIRY" VERSUS THE "LECTURE-RECITATION" METHOD OF EDUCATION

By EDWARD BENNETT

Professor of Electrical Engineering, University of Wisconsin

The Lecture-Recitation Method

The customary method of aiding students to obtain a grasp of any branch of organized knowledge, such as calculus or physics or electrodynamics, is to conduct classes of the *lecture-recitation* type in that subject.

The typical weekly schedule of classes in any one of these subjects may consist of one or more *lecture periods* and two or more *recitation periods.* The lectures are delivered to the entire group of from 50 to 300 or more students who may be pursuing the subject, but for the recitation periods the group is divided into *sections* of from 18 to 24 students each. In the recitation period the student recites on the work he is doing in the subject and has the opportunity to present his views and to bring about a discussion of obscure or difficult parts of the subject.

In the engineering classes in the fundamental subjects, in which there are excellent text-books, the more general practice is to dispense with the lectures and to use all the periods allotted to any subject for recitations. The class in any subject is divided into sections of 18 to 24 students each. In a fundamental subject like mathematics, the student will have five recitation periods per week, each 50 minutes in length. Of the 50 minutes available in each recitation period the instructor uses from 10 to 25 minutes in asking questions, calling attention to features of assignments, eliciting or giving explanations, etc., leaving, say, 35 minutes of the time in which the students may have the floor.

Weakness of the Lecture-Recitation Method

The weak feature of the recitation method of education is that in the typical class of 18 to 24 students, each student may be expected to have the privilege of the floor to exercise and develop his powers of oral expression and exposition in any subject not more than two minutes per recitation, or rarely as much as a total of 30 minutes per week in all the subjects of a full time program of studies.

The most frequently repeated critical comment on the preparation of the engineer grows out of the relatively poor showing which

the typical engineer makes when he is called upon to make an off-hand oral presentation of his views or of his position. Now the mathematical and physical sciences do not lend themselves to the same extent as do the historical and social sciences to free discussion and debate based upon the more common notions and experiences of mankind. Consequently a boy who elects to follow the engineering profession, as contrasted with one who elects to prepare for a career in the fields of law, or of economics, or of political or social science, by this very election, shows definite tendencies. He shows that he is predisposed to activities in which he is dealing with the not easily debatable principles of physical and mathematical science, rather than to the activities of the public forum. His studies in mathematical and physical science serve to confirm his natural tendencies, and undoubtedly the recitation method of education used in the engineering colleges is a powerful factor tending to stunt and repress any tendency toward free and ready oral expression.

In view of this situation, it would seem that an educational method should be used in the engineering colleges which will tend to modify beneficially the characteristics and influences sketched above. With this objective in view, a trial is proposed in one or more sections of certain fundamental engineering subjects of a method which will be called the *Board of Inquiry Method* of education. The features of the proposed Board of Inquiry Method are as follows.

THE BOARD OF INQUIRY METHOD

In the Board of Inquiry Method of instruction, the instructor divides his typical section of 18 to 24 students into three sub-groups of 6 to 8 students each. These groups of 6 to 8 students will be called Boards of Inquiry. Each Board of Inquiry has available for its use at the hours formerly devoted to recitations a small room which is provided with some blackboard space, the necessary chairs, one or more conference tables, and for some purposes with models or demonstration equipment.

Each Board of Inquiry meets in its own room at the customary recitation period and proceeds to conduct an "inquiry" or a "hearing" on the topic from the text previously selected or assigned for that period. For the purpose of conducting the hearing on any topic, such as those suggested in the foot-note,[1] the

[1] The topics set for the hearings will be topics such as "Types of Motion," "Simple Machines," or "Force, Mass, and Acceleration" in Physics, or such as "The Notion of the Derivative," "Maxima and Minima," or "Derivatives of the Circular Functions" in Calculus, or such as "Electric Potential," "Properties of Conductors" or "Motional Electromotive Forces" in Electrodynamics.

Board at a prior meeting has apportioned to its members the following positions for the coming hearing.
Chairman.
Counsel for the Author's presentation or development.
Witnesses and experts for the Author's presentation—1 or more.
Counsel for the Defense Against Erroneous Views.
Witnesses and experts for the Defense—1 or more.

The hearings may be conducted after the manner of the hearings conducted by the Examiners of commissions such as the Interstate Commerce Commission, the Federal Radio Commission, or the Patent Office. The functions of the members participating in the hearing are as follows.

Organization of a Board of Inquiry of 6 to 8 Members

Chairman—Duties of:

A. To preside at the hearing and to see that the rules of orderly and considerate procedure are followed.
B. To pass upon questions of relevancy and irrelevancy.
C. At the end of the hearing to render a statement of the facts disclosed by the hearing.

Counsel for the Author's presentation, methods, line of development or interpretation.

Duties of Counsel:

A. To state briefly what he proposes to establish.
B. To elicit by questoning the Author's witnesses and experts—
 (*a*) the experimental facts relating to the topic,
 (*b*) the interpretation, or the correlating principles,
 (*c*) illustrative examples bringing out the meaning of the principles or showing their applications.

Counsel for the League of Defense against erroneous or unfounded or hazy views.

Duties of Counsel:

A. To state briefly what he proposes to establish.
B. To elicit by the cross-examination of the Author's witnesses and experts, and by the direct examination of his own witnesses and experts, errors, uncertainties, ambiguities, inconsistencies, questionable reasoning, etc., in the case built up by the Counsel for the Author, or by the Author himself, and occasionally to make a case for an alternative and equal or more effective development of the topic.

Witnesses and Experts.

The duties of witnesses and experts will be evident from the statement of the duties of Counsel. A system of knowledge which

has been gradually built up for the purpose of enabling men to get about in safety and in comfort amid the experiences of life, is to mastered. What are these *experiences,* and *what ways of regarding them* have been invented so that experience comes to be comprehensible and predictable as the result of the operation of a few natural laws? This is to be established by the testimony and demonstrations of the witnesses and experts. Witnesses or experts when not on the stand should sit with their counsel to confer with him and to render advice during the examination of the witness who is on the stand.

Reporter.

It is obvious that a record of the "Hearing" is not desired. It will undoubtedly happen, however, that Counsel or Witness will from time to time desire to ask the Chair that an "exception" to his "ruling" be noted. In this case, the Chairman may find it convenient to designate a *Reporter* to record the "ruling" and the "exception"; this record will be discussed and passed upon by the Instructor when he joins the group.

The organization of the Board may be changed daily or weekly, but preferably at the conclusion of the two or more hearings on each fairly brief, well-knit topic.

During the regular 50 minute period, the Instructor will have 15 minutes to sit with each board. He may sit with the chairman, or with either counsel, or may take the stand to testify for either counsel.

It will be seen that under this "Board of Inquiry" procedure, the time available for each student in which to exercise and develop his powers of oral expression is from five to ten times as great as in the recitation method. Moreover, the duties of each member of the Board are such that there is an incentive for him to be alert to everything which transpires, and to come to the meeting of the Board with the topic well organized. The incentive arises from the fact that he has the assurance of the opportunity to use and to test his observations and his knowledge.

The Spirit of the Hearings.

On first reading it may appear that the Board has been so constituted that the interests of the parties to the hearing are in conflict and that the "Hearings" may not rise above the low plane of a petty matching of wits, in which the sense of proportion and of common interest and common purpose is lost. On the contrary, it seems reasonable to expect that the holding of the Hearings in the study of the mathematical sciences will give the members, not

simply a vision, but a rich experience of the high plane upon which an inquiry may be conducted if the method of science is followed. To this end it must be emphasized that all parties to the hearing have a common objective, but that the attainment of the objective requires that the members play different rôles.

The common objective is the appreciation, appraisal and ultimate acquirement of new territory. The rôles which must be played at the hearings in the attainment of this objective have been separated and assigned to different individuals. But these rôles are identical with the rôles which each individual must play within himself. He must in turn and in the same general situation act as analyst, advocate, critic, and judge. Education consists in the balanced development of these powers and in the reconciliation of their demands.

The hearings must be conducted in the fine spirit of accommodation which, in the ardor to reach the heart of the matter, passes over the unimportant and the trivial in order to afford the time for valid criticism and real appreciation. For example, it is a triviality when a witness in the course of an explanation slips and says "right member of the equation," when from his actions it is obvious to all that he meant to say "left member." But it is not a triviality when in the course of developing new concepts, such as those of "electric potential" and "electric intensity," a witness uses the wrong name, or uses the name in a way to indicate erroneous ideas relative to it.

SHOULD ELECTRICAL MACHINE DESIGN BE A REQUIRED COURSE?

By LEONARD DOGGETT

Pennsylvania State College

From the early days when electrical engineering was the growing child of the physics department, through the period of adolescence and on into manhood, electrical machine design has received various degrees of emphasis. At first electrical machine design as a science was non-existent, and had to be built up by such men as Lamme in this country and Arnold in Europe. As the technology of electrical engineering grew in extent, one course after another was added to the electrical engineering curriculum. Eventually, it became top heavy with electrotechnical subjects. Careful selection of material then became necessary. In many a curriculum electrical machine design has now been reduced from a required to an elective course or even abandoned altogether.

And so the pendulum has swung; too far in the opinion of the author. Do electrical machine design courses have any raison d'etre? Should they be allowed to retire in the face of the modern strenuous competition for a place in the curriculum? The author believes that the omission of design courses is a distinct loss to any curriculum, the pruning away of important material for which there is no good substitute. It is pretty generally agreed among all parties now that design courses do not and should not try to produce designing engineers. On the other hand there are important viewpoints that may be had only by carrying through complete designs.

In the first place there is a general *philosophy* which runs through all design. There is no better way briefly of sketching out this philosophy than by exhibiting Table I. This table should in no way be looked upon as a complete picture but it does, however, sketch out some of the high lights. Our engineering graduates should go out with a sympathy and an appreciation for the problems of the designer. To cite an extreme case: an electrical engineer, familiar with electrical design, would hardly specifiy a 100,000 volt alternator, knowing that the stator slots would be so full of insulation that there would be no room at all for copper. Again, no graduate, trained in design, would try to specify a 10,000 Kilowatt, 1,000 R.P.M., Direct Current Generator, because of the impossibility of achieving successful commutation in such a machine.

In the second place there is in any design course the ever present *economic factor*. An excellent illustration of the influence of such

TABLE I.

Illustrating General Process of Design

Specifications	D.C. Generator	Bridge	Aeroplane	Ship
	KW—R.P.M.—Volts at no Load and Full Load—Local Features such as Space Limitations—Operating Temperatures—Watertightness	Span—Width—Loading—Type Natural Features Such as Ice—Wind—Foundations	Maximum and Minimum Speed—Load—Endurance—Ceiling—Special Functions—Manoeuvrability	Carrying Capacity—Speed—Cruising Radius—Draft—Beam—Length—Cargo—Displacement
Experience Data from Similar Finished Products				
Limiting Factors	Heating—Commutation—Insulation—First Cost	Stability—Durability—Clearance Piers or Suspension—First Cost	Safety—Reliability—Supercharger—First Cost	Seaworthy—Operating Cost—First Cost
Activity Factors	Velocity—Flux Density—Current Density	Strength of Materials—Corrosion	Strength of Materials—Power Plant Weight per Horse Power	Space Allotment—Cargo Handling Equipment Strength of Materials
Preliminary Approximations	Drop in Armature and Series Field—Drop in Brushes—Shunt Current	Weight of Bridge	Weight of Power Plant—Wings—Landing Gear—Areas	Engine and Boiler Space—Spaces other than Cargo—Fuel Space
Starting Point	Armature	Trusses—Main Timbers	Wings	Hull
Design of Parts	When the parts are taken up in their proper sequence, each part as finished will in conjunction with the original specifications furnish specifications for the design of the next part. In the d.c. generator design, the design works radially outward.			
Final Check on Limiting Factors				
Final Calculation of Weights and Costs				
Final Calculation of	Efficiency—Characteristics	Factor of Safety for all possible Loads	Factor of Safety for all possible Loads	Metacentric Height—Draft Stability Rolling Period
Repetition of Design with various Activity Factors				

factors is furnished in the way designers choose distribution transformer current and flux densities with an eye to producing the maximum all-day efficiency. Further illustrations of the influence of cost factors are suggested by (1) Limited number of armature and frame diameters for a given line in machines; and (2) Standardized slot sizes and slot numbers. Illustrations without number might be cited of ways of reducing the amount of material needed and keeping down the production cost. Design courses are almost courses in production costs.

In the third place the design student is brought face to face with realities, *hard realities.* Four square inches of copper have to be squeezed into three square inches of space. What to do? The finished machine has too low an efficiency. What to do? The finished product costs too much. What to do? Conflicting pressures are brought to bear on the commercial designer, pressure from the sales force to produce the cheapest machine; pressure from the test force to keep the machine operating satisfactorily. Space limitations, called for in railway or marine practice; speed limitations set up by connected loads; always some inescapable physical facts to be considered in the design. In elementary class room problems a straight line saturation curve is ordinarily assumed for the sake of simplicity. As a matter of fact the saturation curve is not at all straight, and in the design room the saturation curve is accurately dealt with since it is the dominating factor in the design of any electrical machine. A design course is one place where the "whys" and "wherefores" are not sidestepped because of a lack of time.

Perhaps the ideas of the two previous paragraphs might better be summed up under the title of *engineering judgment.* In engineering practice the engineer is always faced by a set of cold physical facts and a group of commercial facts. By the use of his judgment he produces a finished product which gives due weight to all important factors.

Numerical accuracy in calculation is a prerequisite in engineering practice of any sort. Design students usually start off with the happy idea: "What are a few decimal points among friends?" The student is soon disillusioned for at very frequent intervals the results of his calculations are brought into comparison with normal values,. and any great deviation from normal calls for a check. Thus design is one of the few courses where accuracy becomes of paramount importance.

Construction details are best studied in the design room. There, pictures, cross sections, and actual samples of detail parts may be exhibited. Armature winding is much more easily taught in the design room than in the class room. Design is the subject where

TABLE II

DATA ON THE DESIGN OF A LINE OF TWELVE ALTERNATORS

All Machines 1800 R.P.M.—60 Cycle—13,200 Volts—3 Phase

Name of Designer	Name of Customer	Independ. Variable KVA.	(Diam.)^2 × Length	Diam. Inches	Approx. Length Inches	Number Stator Conductors	Number Stator Slots	Turns Per Phase	Stator Current Density	Actual Amp. Cond. Per Inch	Final Length Inches	Watts Per Sq. Inch Stator Coils	Flux Per Pole in Million Line	Field Currents at Full Load and at 100% P.F.	Field Currents at Full Load and at 80% P.F.
N. Green	Newport News Gas & Elec. Co.	10,000	95,500	45	47	432	72	72	1700	1470	45	.32	39	194	241
F. L. Pope	Boston Edison	15,000	135,000	45	66	288	72	48	1175	1470	76	.348	58	289	306
T. C. Martin	Milwaukee Elec. Rwy. & Light	20,000	168,000	45	84	240	60	40	1870	1680	79	High .595	78	245	325
E. Weston	Middle West Utilities	25,000	209,000	48	91	192	48	32	1390	1700	90	.467	91	323	430
E. Thomson	Metropolitan Edison	27,500	229,000	48	100	168	84	28	1460	1580	120	.41	120	334	440
W. A. Anthony	Kansas City Power & Light	30,000	251,000	48	109	168	84	28	1600	1375	126	.387	111	414	478
A. G. Bell	New York Edison	33,000	290,000	50	116	144	72	24	1885	1460	122	.523	121	425	545
F. J. Sprague	Galveston—Houston Elec.	35,000	301,000	50	121	144	72	24	1760	1550	121	Low .125	130	440	578
E. J. Houston	Conn. Light and Power	40,000	334,000	52	124	144	72	24	1700	1695	129	.466	130	440	585
L. Duncan	Penna. Power and Light	44,000	394,000	52	145	120	60	20	1425	1560	138	.403	157	453	540
F. B. Crocker	Phila. Elec.	50,000	438,000	52	163	120	60	20	1780	1760	152	.40	157	520	620
A. E. Kennelly	Brooklyn Edison	65,000	500,000	52	188	Two path 144	72	12	1400	1450	248	.34	260	920	1080

a student may take a bare idea and convert it into something tangible, translate it into dimensions, thus inevitably developing his technical imagination.

Hardly a course in the curriculum could duplicate these advantageous features. In spite of all this, design courses have been decreasing in number and importance throughout American technical schools. Perhaps the difficulties in teaching the subject may account for this to some extent. One of the bugaboos of a design course from the point of view of the instructor is the necessity of checking a multitude of student calculations. A method of reducing this task to a trivial one is suggested by Table II. Here, in the design of a line of twelve alternators, all the specifications save one, the KVA, are made the same. A table, similar to that shown in Table II, is mounted on a drawing board. At each design period each student enters the results of his day's computations. As a rule the entries are either a continuous function of the independent variable or constants that vary within certain small well known limits. A glance down the columns will indicate any anomalous values and call for a check of the calculations by the individual student. This method automatically eliminates the majority of numerical errors and ensures that the finished machine is not a strangely abnormal machine, the product of many a spurious "two" and "ten."

By saving tables of this type from year to year the design office comes into the possession of experience data; such data are always available in a commercial design office, but woefully lacking in college design offices.

The table shown in Table II is an abbreviation of the actual table which has some 40 to 50 columns for 20 to 30 machines. Although abbreviated, it illustrates the principal features of the method. By tabulating customer's names an added touch of reality is obtained. It may be noted that the number of available diameters is limited to four for economic reasons. An alert student, keeping watch of such a table, will gain experience on a whole line of machines, while at the same time he has but one machine to design completely.

In conclusion it may be well to repeat that the design point of view is extremely worth while getting, for the reasons already cited. A design course can be taught with a reasonable demand on the time of the instructor and yet at the same time no major numerical errors escape notice.

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MICHEL, RUDOLPH, Assistant to Director, Cooperative Work, University of Pittsburgh, Pittsburgh, Pa. E. Willis Whited, E. A. Holbrook.

NESBITT, RICHARD E., Instructor in Foundry Practice, Pratt Institute, Brooklyn, N. Y. S. S. Edmands, John W. Burley.

NICHOLS, BEN H., Instructor in Electrical Engineering, Oregon Agricultural College, Corvallis, Ore. R. H. Dearborn, L. F. Wooster.

STEVENSON, ALEXANDER, R., JR., Staff Assistant to Vice President in charge of Engineering, General Electric Company, Schenectady, N. Y. George H. Pfeif, M. M. Boring.

SWARTZ, BLAIR K., Fellow in Personnel Administration, University of Michigan; Research Associate, Employment Bureau, The Detroit Edison Company, Detroit, Mich. A. D. Moore, Benj. F. Bailey.

EDUCATION FOR ANALYSIS IN THE COOPERATIVE PLAN

By ROBERT C. DISQUE

Drexel Institute

It is often assumed that the principal advantages of cooperative engineering education, if not all of them, pertain to the practical knowledge gained in industrial work; and that, therefore, the cooperative plan may be expected to prepare effectively for executive and supervisory positions, but less effectively for positions involving analysis and design. But an experience of twelve years in cooperative education convinces the writer that this assumption, so far as it pertains to analysis, is far from being justified. In fact, there is much evidence to indicate that interest in purely analytical work is stimulated and proficiency therein promoted by the industrial experience inherent in a carefully designed cooperative curriculum.

There are two reasons for this conviction. The first has to do with the refreshing effect of the alternate periods of practical work. When a student arrives at the second year of his college course, he has upwards of fourteen years of almost continuous study behind him—years crowded with intellectual effort. Probably he will not experience another equal period so strenuous, even in his later professional life. The result is a tendency toward staleness—a condition easily recognized as one of the chief causes of the enormous number of failures in the first few years at college. Many students who do well in analytical subjects in high school come, after a short period of college pressure, to resemble an overtrained athlete. Those who drop their college work to take positions in industry or business under these conditions are too likely never to return to their studies; the sacrifice of an apparent opportunity to advance in the outside job seems too great. Some, accepting their decision as final, marry and thus undertake responsibilities impossible to avoid, even temporarily.

This condition is not helped by repetition of courses once taken and failed. What is needed is a brief interim of contact with work of a different nature, subordinated to the student's ultimate motive. By providing an interval of mental relaxation without sacrificing continuity of interest, the cooperative plan avoids the dangers of overtraining. The industrial job is accepted as a necessary part of the whole training period and not as an embarkation upon a

definite career. Renewed interest and vigor are thus brought back to the college work and the crisis is likely to be passed.

But there is also a direct stimulus to theoretical work, especially in the cases of students initially inclined toward analysis. There is nothing like a period of contact with engineering to teach a student the value of knowing, for it is in this contact that he sees most clearly the difference between the trained and untrained mind, in dignity as well as economic value. The theoretical studies in college profit greatly by this experience. Any doubts about the value of theoretical work, and about the authority of the professor teaching such work tend to disappear, and in their place come renewed faith and restored confidence. This is a mighty help to the teacher of theoretical subjects. Students thus refreshed and stimulated, can be led on all sorts of adventures into the highly theoretical reaches of their subjects, if the teacher's enthusiasm and equipment carry any conviction at all. And so there need be no misgiving about the power of the cooperative plan to attract students equipped with analytical minds, and to stimulate and train them for analysis and design.

A CLEARING HOUSE FOR MACHINE DESIGN DATA

Teachers of Machine Design in colleges and technical schools have formed a "Clearing House" the purpose of which is to exchange problems in machine design, research data, ideas as to methods of teaching machine design, and other information of mutual interest. Material contributed by the members is sent to the S. P. E. E. Chairman, Professor Frank L. Eidmann, Columbia University, New York City, and mimeographed copies are distributed to the members.

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

The mast head: Hereafter the "T-Square Page" will be distinguished by a mast head built around the "Arms of the Guild of Drawers." The designer, Professor Thomas E. French says of it: "The blazonry would read: Argent, on a fess sable three triangles of the first. In chief two planes rampant combatant, and in base two pencils in saltire. Crest, on a wreath of the colors a T-square palewise proper. Motto, Gaspard et les droites."

"The study of fundamental spatial relations, whether between abstract points, lines and planes, or their concrete manifestation as beams and columns, shaft of pipe-lines, pulley, plates, roof-members, sheet metal forms, etc., gives the student a camera-like insight that is not to be discounted nor discouraged; but it is far more important that he learn to make this insight function in an active and constructive manner—which means simply that he learn to think. Now, since the attainment of the ability to think clearly can be indicated to the instructor only by the manner of expression used by the student, it is evident that outwardly and practically the aim becomes the development of good expression. This has reference both to the oral and graphic responses."—Prof. F. M. Porter.

Problems in Descriptive Geometry:

Given two non-intersecting, non-parallel lines, *AB* and *CD* and a place *S*. It is required to determine a line *MN* which shall terminate in *AB* and *CD* and satisfy one at a time the following additional conditions:

1. Be parallel to plane *S* and of specified length *L*.
2. Be parallel to plane *S* and of shortest possible length.
3. Be inclined to plane *S* a specified angle θ, and of specified length *L*.
4. Be inclined to plane *S* a specified angle θ, and of shortest length possible.
5. Be inclined to *AB* a specified angle ϕ, and of specified length *L*.
6. Be inclined to *AB* a specified angle ϕ, and of shortest length possible.

---

7. Given any triangle *ABC*. Construct a pyramid *M-ABC* such that the lateral edges *MA*, *MB* and *MC* are of specified inclinations α, β and γ respectively to the plane of the base *ABC*.

---

8. Four horizontal lines taken at random are the horizontal and vertical traces of a plane *T* and the horizontal and vertical projections of a line *AB*. Locate the ground line so that the line *AB* is contained in the plane *T*. —Suggested by Prof. F. M. Porter.

". . . Descriptive geometry has held its place in the engineering curriculum for a century and a half, and while it has yielded time for other purposes, under the constant pressure of an expanding scheme of studies, there has been remarkably little questioning of its grounds for inclusion. Engineering educators have been disposed to grant its claims to value as a rigorous intellectual exercise, as a means of developing and organizing the student's powers of visualization, and as a discipline in precise representation of spatial relations. Language and ideas have very intimate relations; grammar is more than a body of conventions, it is in fact the logic of language. The same principles hold for the language and ideas of space and form, and descriptive geometry has seemed to rest secure on its premises as the grammar of spatial representation."
PRES. WILLIAM E. WICKENDEN.

THE CONTENT OF AN ENGINEERING DRAWING COURSE

By H. M. McCULLY

Carnegie Institute of Technology

The recent summer school, with its highly concentrated program, was so pregnant with prospects for enlarged usefulness for the graphic subjects that I have a sincere feeling that the restrictive influences which were factors in the selection and set-up of course content for Engineering Drawing have been largely dissipated. The papers of Professor Hammond, President Wickenden, and Dean Sackett may be said to indicate clearly, in the aggregate, the general contribution that administrative personnel hope may eventually be realized through proper content. But these papers present only a prospect, hardly a fixed program. Realization of the varied aspects there suggested would depend upon the proper content. I venture the prediction that many of our able departmental executives could readily write an idealistic program that would meet the requirements of such a prospect. It is possible, as has been done by the members of the Division's Committee on Engineering Drawing, to reduce the minutae of such course content to a smoothly flowing sequence of exercises intended to develop to a maximum the blended skill and information which is demanded of Engineering Drawing courses as an essential and prerequisite part of engineering curricula. This content could quite readily be correlated to the suggested objectives, but under no conditions should it be thought that such procedure is needed to vitalize and justify drawing and descriptive geometry as engineering education material.

But, as the writer pointed out in discussing this matter before the conference, these paper set-ups almost wholly ignore the very vital, human elements of the men who teach, and those who are taught. It ignores tendencies, which become more and more obvious with experience, to make every subject sufficiently flexible to meet the rapidly changing condition of modern engineering development.

. . . In engineering practice it is no longer sufficient that a structure or a machine satisfy the requirements of technical formulae. This, of course, will always be prerequisite. But the world today demands that engineering achievement shall catch and express in permanent form the emotional inspiration that lies behind great planning and great doing. Our public today demands

not only the comfort of service which comes from completed engineering projects, but asks for a reflected part of the thrill of their creation. Some call it Art in Engineering. We must comply with this demand to achieve the full share of recognition to which the engineering professions are entitled.

Engineering education can never be otherwise than an integral part of engineering practice. Course content can no more be restricted to formula than achievement will satisfy on the basis of formula only. A group of students, filled with the desire to build magnificently, to create splendidly, filled with the surging desire of youth to go forth and conquer, not dragons or giants or tyrants, but the last challenges of recalcitrant nature, or to discover unknown principles which will increase human happiness, will not be satisfied with a course content which, though perfectly coordinated, yet does not give engineering education an opportunity to display the art of inspirational development. The meticulous drill elements will be gladly endured if the content affords and creates an opportunity for expression, at least between teacher and student, of those things which the student longs to do. Such things will rarely, if ever, come to the surface in mass contact, and course content which is based upon mass teaching alone will not then, I believe, afford an opportunity for this major requirement of our teaching.

Nothing so tends to fix idealism as a component of character as opportunity to express and discuss that idealism with others. In effect, the process becomes a pledge. I feel that if, in beginning courses with young engineers, their consuming enthusiasms can thus early be caught, even in the ephemeral permanence of fleeting words, they will thereby be more deeply and more indelibly impressed in the character of the engineer; and that character will show through every achievement of his later life. . . . And this is the form that the art of the engineering teacher should take, and which, clearly limned, will show against the background of every engineering drawing course.

Course content is not merely a set of sequential exercises so much as it is a conscientious, punctual day by day performance of duties by student and teacher—conscientious, carefully reasoned answers to a prepared problem, and those answers carefully checked.

But repetition of course content year by year breeds monotony—and monotony dulls even the edge of emotional inspiration. No personal contact between two persons can long continue on a plane of enthusiasm where only one party is enthusiastic and interested. It is essential that, somewhere in our set-up of drawing work, some

source of continued interest be provided for the teacher which will match the native enthusiasm of the student.

Mozart in all probability practiced the musical scale faithfully even in his later life but largely because he was weaving its elements into undying symphonies. Rembrandt probably made experimental mixtures of pigments as a preparation for his masterpieces, and I think most drawing teachers would gladly continue to produce excellent teaching results in the elemental drill problems if their departmental organization were such as to include some advanced courses in which they may employ such elements to produce material that satisfied their own wish for expression. There are many courses almost, if not entirely, graphic in their nature which might be given by drawing teachers to satisfy this longing. It must be obvious that to restrain the efforts of a good drawing teacher to the mere finger twitching exercises, while others have the privilege of making the application to the advanced drawing, can only be depressing to him. This depression is soon reflected in the work of the student and the idealism for both is sacrificed to a difficulty readily remedied. These broader courses are in many cases what might be termed "low-level courses" for departments having students in charge. They are frequently used as schedule fillers and lack vitality under these circumstances. This might easily be gained by placing them in a service department where they become a major interest to some instructor.

COLLEGE NOTES

Northeastern University.—Two new buildings have recently been added to the Northeastern University Athletic Plant. One of these, a baseball cage, is located on the site of the University on Huntington Avenue, Boston, and the other, a large new field house, is situated at the University's athletic field in Brookline within two miles of the University.

The administration is greatly pleased by the fact that throughout the industrial depression that has prevailed for some time, the number of companies cooperating with the University has remained practically constant. In some cases the number of students employed by a single company has been somewhat diminished because of business conditions but in relatively few cases have employers found it necessary to discontinue the plan altogether. This indication on the part of employers of their confidence in the soundness of the cooperative plan has been reflected in the wholesome attitude with which the students have faced problems engendered by the economic depression.

The Department of Cooperative Work now comprises eight coordinators who give their full time to the counseling and placement of students and to the maintenance of appropriate relationships with cooperating companies. Two of these coordinators are engaged in the development of cooperative programs for Business Administration students; the others are affiliated with the several engineering curriculums.

The past year has seen considerable refinement of detail in the freshman orientation and guidance program. A Dean of Students assisted by a corps of faculty advisors and a full-time clinical psychologist supervises the new program of freshman work. Problem cases are sorted out early in the freshman year and those who need special diagnosis and remedial treatment are handled individually. Professor Stanley G. Estes, a psychologist of several years' experience in psychiatric measurement with the Judge Baker Foundation in Boston, gives his full time to the University and has charge of this phase of the freshman guidance program. It is expected that the organization for guidance as now set up will not only decrease the mortality in the freshman year but will also enable the giving of helpful counsel to those students whom it seems necessary to drop because of their inability to profit by the programs of study available at Northeastern.

The Tulane University of Louisiana.—Some eighteen years ago the need of field practice in surveying was met by Tulane in the establishment of a Camp of Survey Practice. This was made possible through the kindness of the late Mrs. I. G. Gayden of Oakland Plantation, East Feliciana Parish in this state. Since 1913 attendance at the camp by students of civil engineering at the close of their Sophomore and Junior years has been a requirement.

This modern camp, under the direction of instructors with experience gained from service in the U. S. Coast and Geodetic Survey, the Alaska Boundary Survey, state highway, municipal railroad and commercial surveys, is well known. Some of its features have been considered by other schools contemplating the establishment of something similar. There is nothing new in the idea of a camp of survey practice, civil engineering schools of the better sort have had them for many years. Perhaps we have been more fortunate in the facilities which we have enjoyed and which we feel have contributed much of value to the student's training.

BOOK REVIEW

"*Elementary Electricity.*" By ASSISTANT PROFESSOR E. P. SLACK, Polytechnic Institute of Brooklyn. Published by McGraw-Hill. Price $2.00.

The author has divided this book into ten chapters which include the subjects of direct-current circuits; current; resistance; voltage; D.C. generators; D.C. Motors; Energy and power in D.C. circuits; Alternating currents; Distribution systems and Polyphase apparatus; and the last chapter Vacuum tubes and Radio Reception.

At the close of each chapter is tabulated a list of questions which tend to emphasize the most important principles outlined in the chapter.

The book is non-mathematical. It is very clearly and plainly written so that the beginner may surely understand it easily.

There are some two hundred illustrations including a few photos. The appendix includes instructions for resuscitation by the Prone pressure method.

The book should find application in vocational and industrial schools, among students who have not studied electricity before and whose mathematical training may not have gone beyond arithmetic.

R. C. G.

"LAFAYETTE! WE ARE HERE"

BEN H. PETTY

Associate Professor of Highway Engineering, Purdue University

We at Purdue are hoping that the above title will be the rallying cry of several hundred members and friends of S. P. E. E. on the Purdue campus June 17–19, during the 39th Annual Convention. Our University, the cities of Lafayette and West Lafayette, and the state of Indiana feel highly honored by the opportunity of entertaining this large group of engineering educators and plan to prepare a real Hoosier welcome.

It is true that a great many of those attending these annual meetings still prefer the comfort and safety of railway travel. However, there is an annually increasing number who take to the numerous highway trails via the automobile and enjoy the more attractive scenery, greater freedom and numerous opportunities for stop-overs and side trips this method of transportation affords.

For this latter group some of the major Federal Highways, marked uniformly with the U. S. shield, leading towards Lafayette are listed as follows:

1. *From the North*—
   - (a) U. S. Road 41: from Eagle River on Lake Superior through Green Bay—Milwaukee—Chicago—intersecting 8 mi. S. of Kentland Indiana with U. S. Road 52 leading into Lafayette.
   - (*b*) U. S. Road 31: Mackinac City—Muskegon—South Bend—Rochester—thence by Indiana State Road 25 to Logansport—U. S. 24 to Reynolds—43 to Lafayette.
2. *From the Northeast*—
   - (*a*) U. S. Road 20: Boston—Albany—along south shore of Lake Erie to U. S. 24 S. of Toledo—Ft. Wayne—Reynolds—43 to Lafayette.
3. *From the East*—
   - (*a*) U. S. Road 30 (Yellowstone Trail): Philadelphia—Pittsburgh—Ft. Wayne—U. S. 24 to Reynolds—43 to Lafayette.
   - (*b*) U. S. Road 40 (old National Road): Atlantic City—Baltimore—Wheeling—Columbus—Indianapolis—U. S. 52 to Lafayette.

(*c*) U. S. Road 50: Annapolis—Washington—Grafton, W. Va. —Chillicothe, O.—Cincinnati—U. S. 52 to Lafayette.

4. *From the Southeast*—
   (*a*) U. S. Road 60: Cape Henry—Richmond—Charleston—Louisville—U. S. 31 to Indianapolis—U. S. 52 to Lafayette.
   (*b*) U. S. Road 25: Augusta—Asheville—Knoxville—Cincinnati—U. S. 52 to Lafayette.
   (*c*) U. S. Road 41: Miami—Atlanta—Nashville—Evansville—Boswell, Ind.—22 to Templeton—U. S. 52 to Lafayette.

5. *From the South*—
   (*a*) U. S. Road 31: Mobile—Montgomery—Nashville—Louisville—Indianapolis—U. S. 52 to Lafayette.
   (*b*) U. S. Road 51: New Orleans—Jackson—Memphis—Cairo—Vandalia, Ill.—U. S. 40 to Indianapolis—U. S. 52 to Lafayette.

6. *From the Southwest*—
   (*a*) U. S. Road 80: San Diego—Phoenix—El Paso—Dallas—U. S. 67 to Little Rock—St. Louis—U. S. 40 to Indianapolis—U. S. 52 to Lafayette.
   (*b*) U. S. Road 66: Los Angeles—Flagstaff—Albuquerque—Amarillo—Oklahoma City—St. Louis—U. S. 40 to Indianapolis—U. S. 52 to Lafayette.

7. *From the West*—
   (*a*) U. S. Road 40: San Francisco—Salt Lake City—Denver—Kansas City—St. Louis—Indianapolis—U. S. 52 to Lafayette.

8. *From the Northwest*—
   (*a*) U. S. Road 10: Seattle—Missoula—Bismark—St. Paul—Appleton, Wis.—U. S. 41 to Chicago—to 8 mi. south of Kentland, Ind.—U. S. 52 to Lafayette.
   (*b*) U. S. Road 20: Yellowstone Park—Casper—Sioux City—Dubuque—Chicago—U. S. 41 to 8 mi. south of Kentland, Ind.—U. S. 52 to Lafayette.
   (*c*) U. S. Road 30: Portland—Boise—Cheyenne—Omaha—Chicago—U. S. 41 to 8 mi. south of Kentland, Ind.—U. S. 52 to Lafayette.

Since the Convention falls in the midst of the road building season, no doubt detours will be encountered on several of these routes. Information along this line should be secured locally.

Through the courtesy of the Indiana State Highway Commis-

sion we are in a position to send copies of our own state highway map to anyone upon request. Please address the Office of Dean A. A. Potter. These maps show type of surface on all Indiana state roads, also those county roads which are paved. The map also contains information relative to colleges and universities, state parks, and points of historical interest. Indiana prides itself on having more miles of roads "out of the mud," that is surfaced with gravel, stone or some higher type, than any other state.

In case anyone contemplates travelling via motor bus it may be of interest to know that the Greyhound Bus Lines operate from Chicago through Lafayette to Indianapolis. Connections are made with other transcontinental bus lines passing through these two terminals. Indianapolis boasts one of the largest bus terminals in the country.

For the information of those who expect to come by rail, Lafayette is served by the following steam railroads:

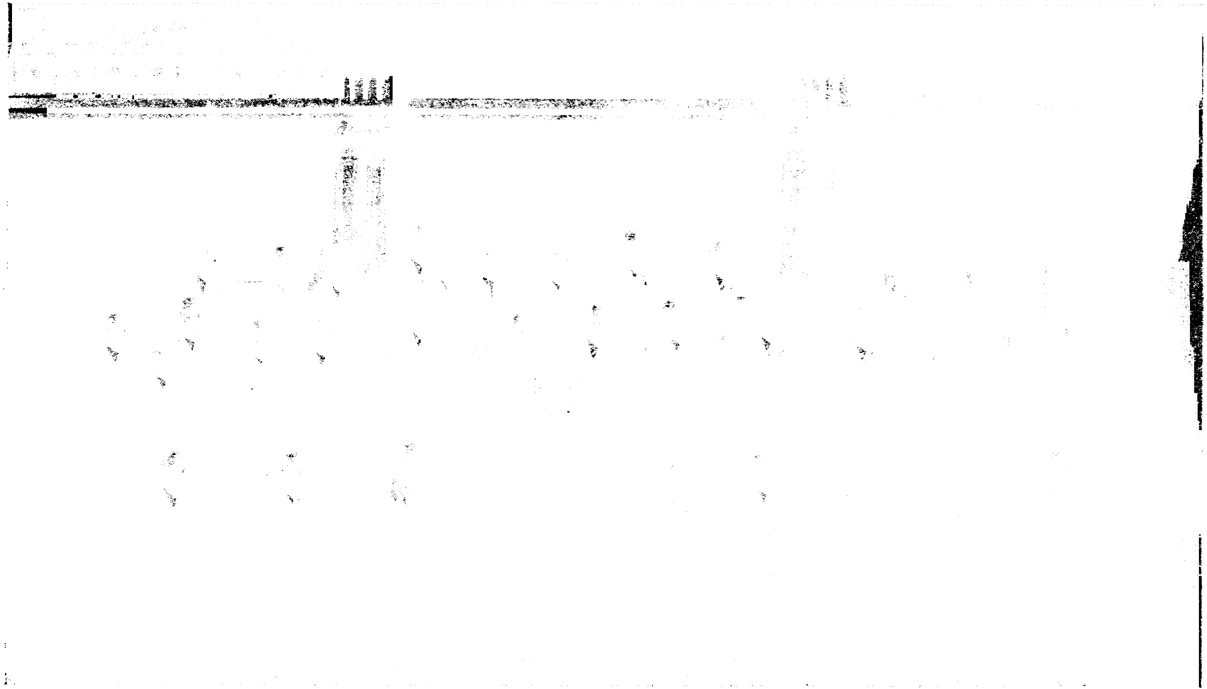
1. Big Four R. R.—Chicago through Indianapolis to Cincinnati.
2. Wabash R. R.—Detroit to St. Louis.
3. Monon R. R.—Chicago to Louisville.
4. Nickel Plate R. R.—Buffalo to Peoria.

Obviously it would be unwise to publish time schedules of arrivals at Lafayette as these are subject to change prior to the Convention time.

If any of those planning on attending this Convention are sufficiently air minded to take to the air, the following information relative to some of the more important lines may be of interest:

1. T. A. T.—Maddux Lines & Penna. R. R.:
   (*a*) New York—Columbus—Indianapolis.
   (*b*) Los Angeles—Albuquerque—Kansas City—Indianapolis.
2. Northwest Airways: St. Paul—Chicago.
3. Boeing System: San Francisco—Salt Lake City—Omaha—Chicago.
4. Western Air Express: San Francisco—Los Angeles—Albuquerque—Kansas City.
5. S. A. F. E. Way Air Lines: Dallas—St. Louis.
6. Embry Riddle Co.: Cincinnati—Indianapolis—Chicago.
7. Stout Air Lines: Cleveland—Toledo—Detroit—Chicago.

Located 150 miles southeast of Chicago and 65 miles northwest of Indianapolis, Purdue is very favorably situated insofar as being convenient to reach via either highway, railway or airway transportation.



Arkansas-Oklahoma Section, Society for the Promotion of Engineering Education. In Session, Stillwater, Okla., February 14, 1931.

ARKANSAS—OKLAHOMA SECTION OF S. P. E. E.

HISTORICAL

During the fall of 1930 Dean W. N. Gladson of Arkansas University wrote to Dean P. S. Donnell of Oklahoma A. & M. and Dean J. H. Felgar of Oklahoma University suggesting the organization of a section of the S. P. E. E. The three Deans took the suggestion before their respective faculties and each faculty approved the idea.

Dean Donnell and his faculty immediately issued an invitation to the Oklahoma University and Arkansas University Engineering College faculties requesting that the organization meeting be held at Stillwater. This invitation was accepted and February 13 and 14 was set as the date.

The following was prepared under the direction of Dean Gladson:

Registration, Dean Donnell's office, Engineering Building.

February 13.

6:00 P.M.

Dinner. Tiger Tavern Annex, Campus.

Address of Welcome by Dr. Henry G. Bennett, President, Oklahoma A. & M. College.

Response by J. H. Felgar, Dean of Engineering, University of Oklahoma.

Introduction of guests by Deans.

7:30 P.M.

Business Meeting, Dean Phillip S. Donnell, presiding.

1. Organization.
   Election of officers.
   Appointment of committees.
2. Organization of an Electrical Engineering Laboratory, by E. R. Page, Prof. of E. E., University of Oklahoma.
   Discussion by W. B. Stelzner, Prof. of E. E., University of Arkansas; H. Naeter, Head of Dept. E. E., Oklahoma A. & M. College.
   General discussion.
3. The Responsibility of the Engineer for the Training of Men for Occupations in Industry on the Lower Levels, by Chas. W. Briles, Prof. of Industrial Education, Oklahoma A. & M.

Discussion by M. E. Farris, Prof. of M. E., University of Arkansas; J. H. Felgar, Dean of Engineering, University of Oklahoma.
General discussion.

4. Design and Construction Projects as Activities for Engineering Students, by L. C. Price, Research Asso. Prof. of M. E., University of Arkansas.
Discussion by V. L. Maleev, Research Prof. of M. E. Oklahoma A. & M. College; W. H. Carson, Prof. of M. E., University of Oklahoma.
General Discussion.

Auditorium, Old Central Building.

February 14.

8:30 A.M.

1. Instruction Methods in Mechanical Engineering Laboratory, by V. W. Young, Prof. of M. E., Oklahoma A. & M. College.
Discussion by J. T. Strate, Asst. Prof. M. E., University of Arkansas; E. F. Dawson, Asst. Prof. M. E., University of Oklahoma.
General discussion.

2. Some Phases in the Teaching of Mechanics, by J. C. Davis, Prof. and Head of Dept. of Mechanics, University of Oklahoma.
Discussion by R. L. Flanders, Oklahoma A. & M.; G. P. Stocker, Prof. of Civil Engineering, University of Arkansas.
General discussion.

3. S. P. E. E. Summer Schools for Engineering Teachers, by W. R. Spencer, Prof. C. E., University of Arkansas.
Discussion by J. F. Brookes, Prof. of C. E.,, Oklahoma A. & M. College; H. E. Flanders, Prof. of C. E., Oklahoma A. & M. College.
General discussion.
Report of committees.

11:30 A.M.

Visit to College buildings and grounds.

12:30 A.M.

Luncheon.

Adjournment.

An invitation was extended by the Oklahoma A. & M. faculty and their wives to the visiting faculties and their wives to be guests in their homes at Stillwater during the meeting. This invitation was pretty generally accepted and this generous hospitality added very much to the social atmosphere of the meeting.

The following officers were elected:

L. C. Price, Research Assoc. Prof. of M. E., University of Arkansas, President.

G. R. Saxton, Head of Dept. of C. E., Oklahoma A. & M., Vice-President.

J. F. Brookes, Prof. of C. E., University of Oklahoma, Vice-President.

W. R. Spencer, Prof. of C. E., University of Arkansas, Secretary.

THE RESPONSIBILITIES OF THE ENGINEER FOR THE TRAINING OF MEN FOR OCCUPATIONS IN INDUSTRY ON THE LOWER LEVELS *

By CHAS. W. BRILES

Professor of Industrial Education, Oklahoma A. and M. College

Society has undertaken, through a system of public education, to train each of its citizens for the responsibilities of citizenship and of workmanship. A complete system of public education, according to Plato, is "a ladder with one end in the gutter and the other in the university." If one should read only this statement from Plato's discussion in his Republic of the function of education the conclusion might be reached that this system of education might mean that everyone should start at the first rung of the ladder—the gutter, and continue to the last rung—the completion of a university course. A further study of his scheme of public education, however, reveals the fact that he has undertaken to establish a system which will prepare the citizens of the Republic to receive the maximum education of which they are capable so that they will efficiently function as citizens and as workers on whatever levels their abilities might indicate. By a series of tests during the period of training the level of one's responsibility and activity is determined. At different points along the way they drop out of formal training and go to work, some remain in training to the age of thirty-five. Those who have survived the suceeding series of tests up to this point are then required to spend fifteen years at work. Then those who survive, scarred and fifty, sober and self-reliant, shorn of scholastic vanity by the merciless friction of life, and armed now with all the wisdom that tradition and experience, culture and conflict, can coöperate to give—these men, at last shall automatically become the rulers of the state.

Since the days of Plato educators, statesmen, and economists have been trying to devise a scheme of education which would afford equal opportunity for every citizen to enter the race of life without the handicap due to the lack of instruction and training.

Abraham Lincoln, who was perhaps the best educated man that this nation has produced, when he was about to sign the Morrill Act which resulted in the establishment of an institution in each state,

* Presented at the organization meeting of the Arkansas-Oklahoma Section, S. P. E. E., February 13–14, 1931.

with Federal grants of land and money for the purpose of giving instruction in agriculture and mechanic arts, made this observation: "Educated people must labor. Otherwise, education itself would become a positive and intolerable evil. No country can sustain in idleness more than a small percentage of its numbers. The great majority must labor at something productive. From these premises the problem springs: 'How can labor and education be most satisfactorily combined?'" Engineering schools are seeking to find a practical and workable plan for the solution of the problem of the combination of theory and practice. An engineering school maintains shops courses in pattern-making, forge and foundry, and machine shop work. The engineering students who take these shops courses receive instruction and training which results in the development of judgments and skills up to the point of appreciation of the relation of such operations to the job of the engineer. It is hardly possible, and it is certainly not expected, that these courses result in the development of doing ability in any of these fields. A further effort to relate work and study properly, education and labor, or theory and practice, is found in some requirement of practically all engineering schools that, before an engineering degree may be granted, a certain amount of industrial experience, evidenced by summer employment, must be secured. Sometimes the type of experience which one secures in order to meet the requirements for graduation does not very closely relate to the work for which he is being trained in his college course. Nevertheless, it is generally held by those interested in the promotion of engineering education that industrial experience, though not closely related to the subject matter of the college course, has some value.

A further effort to more closely relate theory and practice is a requirement that each applicant for a degree in engineering make a tour, sometime during his senior year, for the purpose of visiting industrial plants and getting some notion of types of organization, methods of procedure, standard processes and operations, and general working conditions of some of our leading industries.

I am convinced that one would be justified in the statement that schools of engineering have not fully met the challenge of Abraham Lincoln in the development of workable plans for a satisfactory combination of labor and education. This fact is more fully recognized by the employers of engineering graduates than by those who train engineers. For the past twelve years I have had opportunity to make contacts with employers of labor in industry from the level of the roustabout to that of the general manager. It has been interesting even during this relatively short period of time to observe the evolution of the attitude of the employers toward the engineer. Not long ago the independent oil producer gave little

consideration to expert information of the geologist. I recall that one of our leading geologists in 1918 was invited to address the Redlands Club of the A. & M. College and in that address he stated, with considerable emphasis, that no oil could be produced in regions where the redbeds appear. This information, however, did not deter some of our somewhat reckless wildcatters from seeking to develop gushers in such regions, and the theories of the geologist have been disproven by the fact that the drill bit has gone through the redbeds to producing sands below. Despite this fact, however, the oil producing industry has come so fully to recognize and appreciate the value of science in relation to oil production that you could not get a bid on a lease anywhere unless you have, or there is available, a geology report upon the area in question.

More and more leaders of industry are coming to recognize the value of science and skills in the further development of processes and operations involved in production. A complete solution of the problem lies in a further development of plans of coöperation between employers of labor in industry and the recognized training agencies.

In the development of an adequate plan of coöperation there are certain factors which must be taken into account. These factors apply with equal force to the training of men on the college level or the high school level. They include the following:

1. The training environment should be the same as the working environment.

2. The training jobs should be carried on in the same way as in the occupation itself.

3. The trainee should be trained specifically in manipulative habits and thinking habits required in the occupation itself.

4. Adequate repetitive training in experiences from the occupation fixes habits of doing and of thinking to a degree necessary for employment.

5. The instructor should be master of the knowledge and skills he teaches.

6. Training should be given on actual jobs and not on exercises or pseudo-jobs.

If this list of factors is recognized as applying to an adequate training program on the college level, it becomes apparent at once that there is necessity for a complete scheme of coöperation between productive industry and the engineering school.

But what has all this to do with the responsibility of the engineer for the training of workers on the lower levels? The engineer finds his place in productive industry, as a research worker, as a manager, or as a worker. As a research worker he is responsible for the development of new processes and operations, the applica-

tion and use of which, involves the training of workers in manipulative skill and thinking habits. As a manager he is directly responsible to his organization for the formulation of plans and policies for the training of new workers for old jobs or for the training of old workers for new jobs.

The apprenticeship system of training workers in productive industry no longer meets the needs of modern industrial organizations. This system was never effective except for the training of workers in highly skilled trades.

Perhaps the most important and far reaching provision of the Federal Act for Vocational Education is found in Section 11 of the Vocational Education Act and reads as follows: "At least one-third of the sum appropriated to any state for the salaries of trade, home economics, and industrial subjects shall, if expended, be applied to part-time schools or classes for workers over fourteen years of age who have entered upon employment, and such subjects in a part-time school or class may mean any subject given to enlarge the civic or vocational intelligence of such workers." This provision has made it necessary for those in each state charged with the responsibility of promoting vocational training courses in trades and industries to develop a plan of coöperation between industry and the school. It will be observed from the language of this provision that the two major functions of public education are specifically mentioned "any subject matter which relates either to civic or vocational intelligence" may be given and paid for from Federal funds. The public school of any community has just two major functions, the preparation of the future citizens and workers for responsibilities of citizenship and of workmanship, the development of abilities which will enable one to live and to make a living. In a democracy we recognize, theoretically, the principle of equality of opportunity in matters of education, but while we provide, at public expense, opportunities for the engineer to receive his instruction and training, in an institution supported and maintained by the state at public expense, we do not provide at public expense for the training of workers on the lower levels. This is due to the fact that it is impossible for a high school to equip itself with training facilities in the great variety of occupations which the community affords. Any adequate program of instruction and training for those engaged in productive industry must recognize the necessity for a complete scheme of coöperation between the employer and the school. In the school, instruction is given in related subject matter, science, drawing, and mathematics, and in the shop or the factory, under the direction of the foreman, training is given in the development of skills.

From the standpoint of industry an individual is being trained

so that he may become a more productive workman. From the standpoint of society the individual is being trained so that he may become an economically independent member of the social group. Society is interested, too, in the development of occupational efficiency for the reason that in the last analysis the consumer pays for all inefficiencies in work. This principle can be illustrated nowhere better than the automobile repair and service work which today practically every citizen requires. My car refuses to perform. By some means or other I get it into a garage. I state the symptoms of the case as accurately as possible. The mechanic makes an examination and tinkers with the carburetor, whereupon I pay him for service which he is supposed to have rendered. It soon develops that the car is in worse shape than it was before. I return or go to another garage. You know the rest of the story. You have all had similar experiences, due to the fact that men have not been properly trained and not, as we sometimes suppose, that they do not want to render good service. A four year course in auto mechanics with half time in school given to related subject matter and citizenship courses and half time to work under the supervision and direction of a skilled foreman is, without question, the best procedure for the training of a skilled mechanic and the development of a useful member of society.

And, again, you may ask what has this to do with the responsibilities of the engineer. The engineer is the technical expert in an industrial organization. The engineer is the contact man with the public schools. The school man does not know the job specifications in any industrial organization. He sometimes has little idea of the subject matter relating to any given industry. Superintendent Walter Isle of Ponca City has little conception of the job specifications of the various and sundry jobs listed on the payroll of the Empire and Continental Refineries of that city. Walter Miller, superintendent of the Continental Refinery Company, knows what each man has to do and what each one must know. The engineers in the several divisions of the Continental Refining Company make contact with Fred Heissler, the local supervisor of vocational education, and a course of study is agreed upon which will function in the training of men in the various occupations of that industry. Without the assistance of the engineer and without an intelligent conception of his duties and responsibilities in this field the schools and the industries cannot coöperate in such a manner as to best serve in the training of the youth for the responsibilities both of citizenship and of occupation.

At the beginning of the last school year I was asked by the manager of the Southwestern Light and Power Company, a subsidiary of the Insul Corporation, to assist in the development of a

program of instruction and training which would meet the needs of the men employed in that industry. I agreed to conduct a foremanship training conference with groups of company foremen at Chickasha and Lawton, two days a week at Chichasha, and two days a week at Lawton. This program continued during the year.

Mr. Bernard Lowe, the engineer of Chickasha Division, was a member of the group at Chickasha, and Mr. Fred Huckleby, engineer of the Lawton Division, was a member of the group at Lawton. Mr. Lowe had completed one half of his junior year in electrical engineering at Oklahoma A. & M. College and Mr. Huckleby is a graduate in electrical engineering from the University of Oklahoma. Through the coöperation of these two men and others of the group we were able to develop subject matter in electricity adapted to the needs of those working on the lower levels in the electrical industry. The public schools of Lawton and Chickasha coöperated with the industry in financing instruction through evening classes for those engaged in those occupations, and Mr. Lowe and Mr. Huckleby were the teachers of the groups.

The State Department of Vocational Education published a bulletin giving in outline the subject matter for these groups, and this bulletin has been adopted by the Insul Properties in the electrical industry as a basis for instruction and training of those engaged in electrical trades in that industry.

Mr. Lowe now has leave of absence from his job at Chickasha and is enrolled again in the college where he will complete the work for his degree in electrical engineering. Upon the completion of his course at the college he will then be assigned to an institution in Chicago were employees of the Insul Properties are given further instruction in the application of principles which they have learned in their college course.

It will take time to develop fully workable plans of coöperation between industry and schools both on the college level and on the high school level.

If the theory that the best training is given in the occupational environment and under the occupational working conditions is to be most effectively met, this training should, whenever possible, be given in the occupation itself. This type of school is based upon the proposition that the shop experiences of the students should be obtained in the occupation for which they are being trained and that the other parts of the program should be given in the school. Such a scheme of coöperative education on the high school level is similar to that which was originated by Dean Schneider of the University of Cincinnati.

The lack of coöperation between industry and the schools results in a tremendous economic waste. Perhaps the most conclusive evi-

dence of this statement is the fact that millions of American workmen have turned to the correspondence school for assistance. For a period of the first thirty years of its existence which closed only recently, one correspondence school alone reports a total business of $175,000,000, virtually all of which represents tuition fees from individual students seeking vocational instruction, most of which is for occupations and pursuits in which they were already engaged. This huge sum would maintain a typical American University for about forty years. All of this sum was paid out of the pockets of ambitious, struggling wage-earners, because of the failure of industry and the school to serve their needs adequately. This, too, in a country where we boast that education is democratic. In the year 1922, alone, three correspondence schools collected a total of more than $25,000,000 in tuition fees. Assuming an average payment of $40.00 by each student enrolled, which is a liberal estimate, these three schools enrolled, for the one year, alone, more than six hundred thousand students, a group almost as large as the total number of students registered that year in all of our higher institutions of learning.

Leaders of industry are ready to meet the leaders in fields of education in the development of a system of coöperative training which will meet the needs of every individual, whether on the high school level or the college level. In the development of this program the engineer, the technical expert in the field of productive industry, will play a most important part.

DESIGN AND CONSTRUCTION PROJECTS AS ACTIVITIES FOR ENGINEERING STUDENTS *

By L. C. PRICE

Mechanical Research Engineer, University of Arkansas

Introduction

The instinct to "belong," and the instinct to "do something," are among the oldest and most deeply rooted of all human tendencies. The small boy may profess to hate his school, and to hate to study, and to hate his teacher, yet—at heart—he is loyal to that group with whom his lot is cast, and is ready to defend it and its doings, both verbally and physically, against any stranger who may have the temerity to deprecate either. Within the school and within the neighborhood, boys of similar tastes often form small groups, or clubs, occasionally with the simple incentive afforded by congeniality, but more often with the object of "doing something." Typical of these is the Little Scorpions' Club of the Toonerville boys, in the Sunday comics. One of the strongest arguments in favor of the Boy Scout movement is the fact that boys are bound to be doing something, on their own initiative. Proper guidance can direct their activities into useful channels. Lacking such an outlet for their energies, it is extremely likely that they will band together for purposes useless, if not actually vicious. This instinct for organization and for "doing something" persists throughout life.

So the engineering student in college is not likely to be satisfied simply to study his lessons and recite them in class. His scheduled work must be heavy indeed if he is unable to find some spare time in which to do as he pleases. It is extremely doubtful if this condition ever exists or if it would be a good thing if it did. However small may be the amount of spare time the student is able to squeeze from his scholastic duties, if he has any initiative or is at all worth while, he will somehow find enough time to enable him to belong to an organization or two, and to engage in some sort of outside activity. Industrial executives know this, and in hiring engineering graduates, will usually give preference to those men who have either worked their way through school, or have been active in student organizations, or have proved their independence

* Presented at the organization meeting of the Arkansas-Oklahoma Section, S. P. E. E., February 13–14, 1931.

in some other way. The plodder who has done no more than what he was told to do, must have made grades far above the average if he is to receive much consideration.

Activities Open to Engineering Students

Many forms of activity present themselves as candidates for the student's attention. We will here consider a few of those in which the engineering student may engage.

First, his financial state may be such that he must work in order to support himself while in college. In that case, he will have little time to devote to the non-essentials, and the very fact that he persists in going to college under such a condition is pretty good proof of his courage and industry. Such men may not make the highest possible grades while in college, due to the demands on their time, but it has been my observation that those who are able to finish are above the average, both in scholarship and as all-around men.

Not all students do, or can, go out for athletics, but for those who do, this activity is probably next to self-support in order of importance. It is not the purpose of this paper to discuss the merits, or otherwise, of intercollegiate athletics, but it is generally admitted that the training in leadership and coöperation is of value to those who take part. It is often argued that athletics take too much of the student's time from his studies, and this is undoubtedly true in some cases. Almost all of us, however, know of athletes who have made exceptional grades and have had scholastic honors bestowed upon them. Dramatics, debating, and journalistic work are among the many other activities in which students may engage.

Student branches of the professional engineering societies offer one of the most valuable outlets for students of engineering. In this work the student gets training in leadership and in writing and public speaking, a better perspective of the field for which he is fitting himself, acquaintance with current literature in his chosen field, closer contact with his teachers, and last, but by no means least, an acquaintance either personally or by reputation, with the highest type of men in his profession. An engineering graduate who is able to point to a record of activity in his professional society has, in that fact, a valuable recommendation to prospective employers. A graduate who has not been a member of one of these societies is almost sure to be regarded with the suspicion that there must be something wrong.

Journalistic work in general has already been referred to. Nearly every engineering college has its journal of engineering, edited and published by students, and many of the articles in these

journals are written by students. Work on the staff of such a publication constitutes one of the most profitable of activities for the engineering student.

The Need for Creative Work

In addition to his interest in all the professional and other activities which have been mentioned, nearly every born engineer has a natural desire to design something or to make something. If he can turn out a design or a machine that he can truly call his own, or if his group can produce something truly their own, the work arouses an interest, and the completion of it a satisfaction, which are seldom produced by other forms of activity.

Of course, there are construction problems and design problems in every engineering course. It is seldom, however, that any such design ever exists except on paper, or that the ordinary shop exercises are ever such that the student can see the parts fitted together into a finished machine. There is danger, therefore, that the end toward which the student strives may be not so much to design or make a good machine, as to please his instructor. Of course, this is not always so, and may not apply in even a majority of cases, and actually these two ends should coincide, but I submit that too often there are cases where need for excellence in the finished product is obscured in the student's mind by his craving for a good grade, which he knows he can get only by pleasing his teacher. Furthermore, classroom design and construction problems are necessarily pretty well cut and dried before being presented to the student, so that his interest may not be aroused to the extent possible were he the originator, or one of the originators, of the project. Moreover also, the thing may be irksome to him simply because it is something he must do. Doing what one must, rather than what one wants to do is necessary all through life, and may be conducive to strength of character, but a steady diet of it without any chance to exercise one's own initiative in creative work, will not go far in developing leadership.

The writer must here take the defensive long enough to state his position clearly. In the first place, he is not arguing against classroom work in design and construction. The thing a boy is supposed to come to college for is to learn by being taught. It is realized, also, that the engineering student will, upon graduation, take a subordinate position where he will have to work on problems outlined for him by his employer. It is true, furthermore, that all through life, whatever his position, he will be compelled to perform many tasks that are irksome to him and which seem to him to be of no account. It is also true that, of all the graduates of an engineer-

ing college, only a few will attain to positions of high leadership. The rest will always have to follow. A professor in a certain college was once quoted as saying, "We are not training men to be railroad employees; we are training them to be railroad presidents." If all engineering graduates—or even all the graduates of that institution—became railroad presidents and captains of industry, the demand for such would be somewhat oversupplied. And in college there will be some who are content merely to follow, and to do only the required work. A professor in an engineering college in the Southwest wrote recently, "Some men never do a stroke outside of required work, and we usually do not worry too much about such dull fellows,—there are enough of the other sort." It is with regard to that "other sort,"—the boys who have ideas of their own, and courage and industry enough to carry them out, that this paper is written. If their college cannot give them advice, encouragement, and facilities to carry out their ideas, it is unlikely that they will find these anywhere else.

To allay the suspicions of any who may fear that the writer is advocating an undue emphasis on shop work, it must be said that it is realized that the value of shop courses is often debated, and that some engineering schools have no shops at all. Certainly it is not the function of a university to turn out finished mechanics, and the main object of shop courses is, by familiarizing the student with shop operations, to enable him to design and to plan production with due regard to the possibilities and limitations of the shop. What he does advocate is that if an engineering student has an idea that he wants to work on, or if a group of them have such an idea, they should be able to find a sympathetic faculty, and if their wants are not too elaborate, they should be allowed to follow it up. A distinction may have to be drawn between the boy who simply wants to make trinkets such as bookends or other ornaments, and the one whose idea is a real engineering problem. It is to the latter that this paper refers. Sometimes such a problem may be undertaken as a thesis. Again, it may be too small for thesis credit, or possibly it may be something that the boy simply wants to carry far enough to try out. In either of the latter cases, if undertaken, it will probably have to be carried on outside the curriculum.

Advantages and Disadvantages of Extra-Curricular Engineering Projects

It is natural that there should be some objections to encouraging or even allowing students to carry on work of the kind referred to above.

Chief among these is an argument which is often cited against other forms of student activity; namely, that the participants may become so interested in the outside work that their studies will be neglected. This claim is perfectly legitimate, as human nature insists on being interested in all byways that lead aside from the path of duty. It is much nicer to work on one's own ideas than to prepare a lesson in mechanics, thermodynamics, or some other fundamental science. Nevertheless, this tendency to pursue some fancy to the detriment of one's class work is controlled in the case of other forms of activity, such as athletics, and it seems reasonable to conclude that proper control can be exercised over extra-curricular engineering projects as well. Indeed, it is doubtful if a student would be as likely to be led astray by a project related to his chosen work, as by social activities or some other less-serious campus goings-on. In the first place, probably only the more serious-minded students would have initiative enough to want to start any work of their own, and in the second place, the authorities can hold up such a privilege as a reward for those whose class work has been and continues to be above a certain grade.

Other arguments advanced against such work are that the students may lose interest and not complete their project, and that such projects are rarely small enough to be completed by any one group. These possibilities make necessary, first, careful faculty guidance in the choice of a project, and second, that the student or group be made to understand that they must not start such work without the determination to finish it. It is recognized that these conditions, particularly the latter one, may not be so easy to fulfill.

Considerations of safety in such work undoubtedly call for careful faculty supervision except possibly in the case of one or two of the most advanced and trustworthy students, and may necessitate limiting the number of students working independently at any one time. Another fact which calls for a sympathetic faculty is that students are seldom advanced mechanics, nor are they usually capable of carrying out a design without faculty suggestions and assistance.

There appear, however, to be a number of advantages in favor of such work when the aforementioned difficulties can be surmounted. Some of these have already been presented as favorable arguments and will only be mentioned here without comment.

It almost goes without saying that such projects give a student additional training in design and construction over what he gets in the regular courses. Working on his own initiative must also tend to stimulate his imagination and creative ability, and to develop his initiative. It must give him a definite incentive, and

therein is different from class work, as the ultimate object becomes the finished product rather than pleasing the instructor. It teaches coördination, as each man knows that the part he is designing or making must fit into the finished structure, and perform its function there. Other favorable arguments are those which apply also to Engineers' Day Activities, which are looked on sympathetically by many institutions, in spite of their interference with class work. These, as stated by a professor at one of the southwestern schools, are that such work teaches the student coöperation, the handling of men, working against time, and is a fine advertisement of the school.

Results of a Survey of Engineering Colleges

Recently, in an attempt to shed some light on a debatable matter, a survey was undertaken by the writer in which letters were sent to the deans of engineering in sixty-eight American colleges and universities, asking for a statement of the official attitude of each institution regarding extra-curricular engineering projects, and for an expression of opinion from each dean as to the advisability of encouraging or allowing students to carry on such work. The three institutions represented at this meeting were purposely not included in this survey, as their attitudes will, no doubt, be stated in the oral discussions. To date, fifty replies have been received to these inquiries. Twenty of these expressed themselves as being in favor of work such as outlined above, sixteen advised caution, ten were not favorable, and four were irrelevant. It was found impossible to classify any of the groups as to either geographical location or size of school. For instance, in the favorable group there are large schools and small ones; schools in the East, Middle West, and far West; old schools and new ones. The same is true of the other groups. The attitude of each seems to be simply the result of its own experience and the opinions of its faculty. It may be mentioned here that six of the favorable group and six of the cautious ones reported that groups of their students had built or were building gliders or airplanes.

Possibility of the student's tendency to neglect his studies for the outside work was mentioned by ten out of the sixteen cautious ones, and by six of the ten who were unfavorable. Other reasons advanced by these two groups have already been mentioned; namely, the question of safety, possibility of the students' losing interest, improbability of students being able to carry through either design or construction without faculty assistance, and the fact that it is very easy to choose a project so large that it cannot be finished by any one group.

Most of the arguments in the "yes" group have also been mentioned. A few others will be quoted. The dean of a large school in the far West writes, "I look upon this type of work as a means of instruction and not as a means of developing skill. . . . I am quite sure that the enthusiasm which is exhibited leads the student to do a great deal more, as a usual thing, than that for which he gets credit." The dean of engineering in another large western school writes, "My view is that this is the most valuable form of student activity." From a middle-western school in which 1100 are enrolled in mechanical engineering alone, "I have known of cases where the encouragement of projects such as indicated above has resulted in lowering standards, but in general I believe that the good from such projects more than makes up for the dangers which may result. . . . In general, every encouragement is given at this institution to students who are interested in using their own initiative."

Experiences at the University of Arkansas

In the spring of 1929, members of the A. S. M. E. student branch at the University of Arkansas wished to undertake, as a group, the making of some sort of an airplane engine. The Mechanical Engineering Department felt that such a project might stimulate considerable interest among all the M. E. students, as well as be of benefit to those taking part, and so sanctioned the idea. The engine was designed partly by the students and partly by the writer of this article. It is unnecessary to state the details of the engine, except that it is of the radial type, has five cylinders, and is air-colled. It was designed so that all parts could be made in the University shops except the pistons with their rings and pins, valves and valve springs.

The Mechanical Engineering Department has allowed use of the shops for this work. Supervision has been by members of the department and by the writer of this paper. Night work has been held down to one night per week, from seven to ten o'clock. Attendance at the night sessions has averaged about six. A few of the boys have put in spare hours in the daytime or drawings, patterns, and machine work. The design was finished some time ago, and all drawings have been traced and printed. The crankshaft has been finished. It was cut from a piece of 8-inch shafting 44 inches long, and is made in two parts, fastened together at the crankpin in a tapered and keyed point. All the connecting rods also have been finished and assembled. These were cut from solid pieces of steel—the master rod from a piece of 6-inch shaft. Several smaller parts, patterns and castings, have been completed.

Patterns for the cylinder head and cylinder barrel have also been finished. One of the boys has, with the help of a few suggestions, designed a machine to grind the cams, and has made the master cams and completed the machine. This job is an exceedingly creditable piece of work.

I confess frankly that a project as ambitious as the one outlined above is too large. The boys would probably have taken more interest if one group could have finished the job, or if those who were juniors at the start could have seen the completed machine before graduation. Still, the work is probably going on as fast as could be expected under the circumstances. There have been no accidents, no tools lost or broken, and members of the teaching staff do not notice that any of those taking part have fallen down in their class work.

On the other hand, several of the boys have expressed themselves as feeling that they had learned a great deal from the work that they did not get in class. The Fall after this work was undertaken, two senior M. E. students registered for senior thesis, which is an elective at this institution, and selected as their problem, one having to do with internal combustion engines. At the same time, two students in electrical engineering registered for thesis work. It is my understanding that these were the first theses undertaken at this institution in several years. During the current session of 1930–31, there are two M. E. students and one in civil engineering doing thesis work.

Registration in the Engineering College of the University of Arkansas in the Fall semesters for the past three years has been as follows: 333 in 1928, 330 in 1929, and 293 in 1930. In the same years, membership in the A. S. M. E. student branch of the same institution has been 14, 22, and 28 members. In other words, while the registration in engineering has decreased 12 per cent, student membership in the A. S. M. E. has doubled. It would be unwise indeed to claim that the increased interest in thesis work and in mechanical engineering is in any way due to our airplane engine project, but in view of the admitted debatability of the whole question, I cannot refrain from presenting these figures for whatever they may be worth.

Summary

In this paper the attempt has been made to show that:

1. All students are very likely to have some spare time on their hands, which those with any initiative will use in pursuing outside activities of one sort or another.

2. Many engineering students have a desire to design or make

pieces of machinery, or have ideas of their own as to possible improvements in existing machines, or wish to get certain information by experiment.

3. Proper encouragement by a sympathetic faculty in carrying out their ideas may increase their interest to such an extent that they will use time otherwise wasted or put into non-essentials, to work out their ideas on the drawing board and in the shop and laboratory.

4. Such encouragement and allowing them to undertake outside projects has some dangers, principal of which is that they may tend to neglect their studies.

5. This tendency to neglect studies can be controlled by proper faculty supervision, and the student's engagement in some engineering project on his own initiative is likely to develop his creative ability and to increase his interest in his chosen work.

6. Such a project has, on the whole, been successful at the University of Arkansas.

DISCUSSION

By W. H. CARLSON

Professor of Mechanical Engineering, University of Oklahoma

In discussing this paper I will refer to the conclusions:

1. Students are very likely to have some spare time on their hands which with any initiative they will use in pursuing outside activities of one sort or another. It is very true that all students have spare time on their hands. Oftentimes the poor student thinks he has more spare time than the better student actually has, so if students are permitted to work on projects of any kind, one should be very careful in selecting the students who can give the time without affecting their studies.

2. Many Engineering students have a desire to design or to make pieces of machinery or have ideas of their own as to possible improvements in existing machines or wish to get certain information by experiment. This statement is very true and is general for most students taking Engineering.

3. Proper encouragement by sympathetic faculty in carrying out their ideas may increase their interest to such an extent that they will use time otherwise wasted or put into non-essentials to working out their ideas on the drawing board or shop or laboratory. If a student has an idea that he wants to carry out in the shop or laboratory he does not need much encouragement, for if given access to the shops or laboratories he will immediately attempt to carry out his ideas.

4. Such encouragement, as allowing them to take outside projects, has some danger, principally that they may tend to neglect their studies. My experience has been that the time actually spent in the shop or laboratory would hardly be sufficient to cause a student to neglect his studies, but it is the time he spends in thinking of improvements on his project when he should be studying thermodynamics, electrical engineering, etc., where the greatest amount of time is consumed.

5. This tendency to neglect studies can be controlled by proper supervision by faculty and the student's engagement in some engineering project on his own initiative is likely to develop his creative ability and to increase his interest in his chosen work. We speak of proper faculty supervision. In the first place if there are one hundred or more students enrolled in a school and with the present teaching load that the faculty must carry along with other duties, it is impossible to give many students the time that would be required on a project in the shops or laboratories. It is often argued that if too much shop work is given to a student he will only become a glorified mechanic. This may be true, but I do not believe that there are any colleges of engineering that give sufficient shop work to develop a man's skill to a point where he could be classed as an expert. I am wondering, however, if there are not other methods of arousing the personal initiative of students in addition to shop work and laboratory work, such as permitting him to spend considerable time in the library gathering information for a thesis on the subject that he is most interested in, laying special emphasis on articles in the recent technical journals. By doing this the student would feel that he was being brought up to date and, too, he would become accustomed to working through the mathematical analysis of various problems made in the field. It is common knowledge that very few engineers in practice take the time to work through the mathematics of most articles after graduation either from lack of time or confidence, or ability to understand them should they take the time. If a student was capable of working these out while in school he would feel confident of his ability to work and understand them after leaving, which would be of value to him.

MINNESOTA BRANCH S. P. E. E. MINUTES OF THE FIRST 1931 MEETING

President Geo. C. Priester, Professor of Materials of Engineering, presiding.

The first meeting of the Minnesota Chapter of the Society for the Promotion of Engineering Education for the year 1931 was held Thursday, March 5.

Dinner was served at 6:30 P.M. at the Campus Club.

The question under discussion was "Training our graduates to meet the demands of the past, present, and future engineering problems." The subject was presented by Professor J. M. Bryant, Professor and Head of the Department of Electrical Engineering, and Professor C. A. Mann, Chief of the Division of Chemical Engineering.

After the Secretary read a discussion prepared by Professor F. W. Springer of the Department of Electrical Engineering, the heads of the degree-giving departments continued the discussion of this interesting and practical problem, in the following order:

Prof. J. R. DuPriest, Mechanical Engineering Department.
Prof. Frederic Bass, Civil Engineering Department.
Prof. John Akerman, Aeronautical Engineering Department.
Prof. F. M. Mann, Architectural Department.

Prof. Andrew Boss, Agricultural Engineering Department, ended the discussion by making a summary.

Meeting adjourned at 9:45 P.M., Central Standard Time.

CHAS. F. SHOOP,
Secretary.

DISCUSSION OF "TRAINING OUR GRADUATES TO MEET THE DEMANDS OF—FUTURE ENGINEERING PROBLEMS"

By F. R. SPRINGER

Professor of Electrical Engineering

It is obvious that only those graduates who both *can* and *will* are likely to have very much to do with the solution of the future problems. For this reason it would seem profitable to all concerned to use a system of college training which would limit its graduates to the *can* and *will* type. Other schools and places take care of those who cannot or will not.

College diplomas cannot take the place of fitness, will-power and training but diplomas should be a measure of *all* such characteristics. A successful system of college training should at least offer no advantage to dishonesty, parasiting, short-time memory or to mere cleverness, but *diplomas should give distinct recognition* to *judgment, courage* and *will power* as well as to *knowledge* and skill, because such characteristics are essential to success.

In order to put ourselves in a properly humbled state of mind it might help us to make an inventory of the graduates with whom we have had personal contact, following their respective changes in positions of success and failure over periods of 5, 10, 15 and 25 years, and then honestly considering how much the last problem of the last course had to do with their respective successes or failures. We would undoubtedly reach the conclusion that the causes generally laid much deeper than any course we may have offered. While the engineering student can be identified by the inevitable slide rule, only a comparatively few of our older successful graduates seem to have such devices handy. Our older banker friends seem to have little connection with ledgers and cash registers. One is compelled to wonder just what particular hereditary traits, information and training in college really are fundamental to success and what we are doing about it.

It seems to be generally agreed by both teachers and employers that "fundamentals" constitute the real essentials. Possibly the following:

1. A knowledge of the physical theory, equal to the feeling and knowledge of a trained musician for the performance of a musical instrument.

2. Ability to express conventionally such physical theory by words, diagrams, mathematics, etc., as may be desired by the individual or as required by circumstances.

3. Ability to apply such theory in competition.

4. Ability to move among people with a minimum of friction, requiring a training in the conventions and principles of society and of business and a suitable personality.

With these fundamentals, students are likely to succeed, but does our system select, train and recognize the essential qualities that make the above fundamentals possible—*i.e., judgment, courage, will power* and *knowledge* and *skill?*

It is true, of course, that different students can and will do, very satisfactorily, quite different types of work. Also, each branch of engineering has places for many kinds of real knowledge and skill, and *all* branches offer opportunities for the exercise of judgment, courage and will-power. It follows that it is not fair to limit graduates, in any field of engineering, to a *narrow* required course.

When one considers the range of talent from Faraday and Edison to Maxwell and Heaviside, it is evident that much care should be exercised in selecting a basis of elimination of the unfit. It would be just as unwise to dismiss the Faradays as to hamper the Maxwells. Colleges of Engineering should not be impossible places for geniuses. Hence, courses should be so arranged, for the good of the State, so that all kinds of the fit shall have their chance. This, to some extent, begs the whole curriculum question but, at the same time, emphasizes the idea that the value of judgment, courage and will-power should be measured by a diploma as well as knowledge and skill, and memorized prescribed information.

Our present American paternalistic (or maternalistic) system of education seems to go too far in trying to machine-make big ones out of all little ones who apply. Much of the "*can*" is supplied the students in solving assigned problems and many administrative rules and direct pressure bolster up weak "*will.*" Our system is like that of a rich father who deprives his son of those conditions which make the father successful.

We are probably drifting slowly towards a modified continental system of training which does not pretend to make any graduates successful, as future leaders, except those who *can* and *will.*

Without going into many important details, let us imagine a system, applied, possibly in the junior and senior years, in which students might attend lectures and recitations, take quizzes and solve problems and even receive informal grades from their instructors but who would not be *compelled* to attend classes, and whose graduation would depend upon passing comprehensive examinations by committees, at the end of one year or of two years.

Naturally, such a system would eliminate almost all except those who both *could* and *would.* Others would not likely even come up for the finals.

Further, imagine the position of the teacher upon finding few students attending his classes and possibly learning that they were getting instruction in some other place and way, if they so desired.

Such a system would cause revolutionary changes for administrators, teachers and students, and personal responsibility would be greatly increased, with the results already mentioned.

Training students to meet the future demands in our country, already characterized as having the greatest wealth, the most expensive education and the greatest amount of crime, is certainly not a trivial matter and some means must be found such that only those who really can and will solve the future problems shall be rewarded, and that "success," even in acquiring a diploma, shall go to no other kind of graduate.

Are American engineering teachers afraid of such a system?

P.S. March 22, 1931.

One of the first of the "important details" referred to above in connection with the consideration of the adoption of a "modified continental system" for undergraduate engineering courses, would be the question of a proper foundation. Engineering teachers generally have little faith in the idea that merely exposing students to four years of high school, or college environment, would likely result in their catching even a diploma's worth of real knowledge and skill. Further, it is not probable that very many teachers would favor the adoption of a modified continental system even in the junior and senior years, without a substantial improvement in the fundamental training during the freshman and sophomore years, which in turn rests upon the high school.

Students entering a College of Engineering on high school diplomas are bound to represent a very wide range in inherent ability and fitness, and in preparation, both as to subjects and to kind of instruction received in the high school. There can never be any doubt about this condition.

Rigid entrance examinations might solve the problem if they were politically possible in State institutions, but few would care to face the upheaval which would result if such a method of selecting candidates were adopted at present. Besides, it would be futile, in many cases, to send students back to their respective high schools where the required subjects may not be taught at all or not taught very well for the purpose.

Another method would be to register high school graduates having diplomas, as now, and then to give all of them "*placement*" examinations, lasting one or several weeks, as to natural fitness, training and subject preparation. This would voluntarily eliminate quite a few students. Others could be given a ("sub-freshman") defeminized engineering college preparatory training. Of these, some would be able to graduate in four years by taking summer school work.

An increasing number of students, especially from certain high schools, would be found prepared to enter the regular engineering freshman courses. This is really the key to progress.

In conclusion, it does not seem probable that a modified continental system will be very seriously considered until the entrance requirement situation is on a different basis than at present. High schools have other things to worry about, which raises the question—

What are engineering teachers going to do about it?

F. W. S.

PROFESSIONAL ETHICS AND PRACTICES IN ENGINEERING *

By ANSON MARSTON

Dean of Engineering, Director of the Engineering Experiment Station,
Iowa State College

The professional organization of engineering has matured very rapidly since 1900. A large and increasing proportion of the work of our great national engineering societies is now devoted to the professional as distinguished from the technical activities of our profession. Our state governments, with engineering license laws administered by boards of engineering examiners, and our engineering societies, with formal codes of engineering ethics administered by standing committees on professional conduct, are exercising more and more definite authority over the competency, the ethics and the professional practices of individual engineers. It has become the duty of our engineering colleges to educate their engineering students before graduation in professional ethics and professional practices.

Engineering a True Profession

Engineering is the profession most characteristic of modern civilization, and its recognition as such is now widespread. Engineering is at once the oldest and the youngest of the great professions: The oldest, because the invention and the use of tools and other mechanical devices was the most essential characteristic of the rudest beginnings of civilization; the youngest, because in former times mechanic arts and artisans were held in contempt and only in comparatively recent times has engineering achieved recognition as a true profession.

A *profession* is a life calling of such character that its practice is and should be confined to an organized body of men who, by reason of thorough educational training of advanced character and by extensive responsible experience, have attained high scientific and technical qualifications for their special work and from whose ranks the unfit and the unworthy are rigidly excluded.

The *origin* of the term profession is the fact that the members of a profession "profess" that they have the high qualifications needed to practice in their professed calling.

* An address delivered at the Civil Engineering Session of the Summer School for Engineering Teachers, Yale University, July 2, 1930.

The origin of the words, "engineering" and "engineer" is such as to indicate that the engineer should be thought of as primarily a man of genius, or possessing ingenuity, and that engineering should not be considered as merely an art.

The words * "engineering" and "engineer" come from the Sanskrit *jan*, to be born, from which the Greek form *gen*, and the Latin, *gen*.

"The direct line of derivation (of the word, engineer) may be traced to ingenium—natural capacity, talent, capacity for invention—and is closely linked with the words *genius* and *ingenuity*." †

The name "engineer" came to us from the Latin through the French noun *ingenieur*.

It is a mistake to think that the name of our profession is derived from the word *engine* or that the engineer is primarily concerned with engines. An engineer is an ingenious man, a man of genius. An engine is an ingenious machine.

Some of the professional characteristics of engineering are repeated here from the writer's lecture of yesterday (July 1, 1930,—"The Aims and Purposes of Civil Engineering Education").

Professional Characteristics of Engineering

1. A great system of engineering education.
2. Increasingly widespread requirement of governmental professional licenses to practice engineering.
3. A great professional engineering literature.
4. Many local and several great national professional engineering societies in each great country.
5. Increasingly strict formal codes of engineering ethics, more and more punctiously enforced.

Engineers' License Laws

Twenty-five states of our country have already adopted engineers' license laws, and thinking engineers now generally agree that such laws will in the future be universal in our country. Already some of the first laws passed have been revised, and it may be anticipated confidently that they will continue to improve and to become more stringent. Present engineers' license laws leave much to be desired in the qualifications which they lay down for practice, and their effective and equitable enforcement is still imperfect.

* *Life of Sir William Fairbairn,* by Dr. William Pole (Abridged), Minutes of Proceedings, Inst. C. E., Vol. CLXXIX, 1909–10.

† *Bulletin No. 16 of the Investigation of Engineering Education,* Society for the Promotion of Engineering Education, 1929.

Undoubtedly both their requirements and their enforcement will improve materially with time.

One weakness of present engineers' license laws is the "grandfather clause," entitling engineers already practicing in their state before the passage of its license law to receive licenses without any final examination. This, however, is a temporary situation merely. The "grandfathers" are dying off rapidly. Another weakness is the present extensive exemption of large classes of salaried engineers.

The state agency for the administration of its engineers' license law is universally at present a state board of engineering examiners, of many of which one or more engineering professors are members.

Twenty of the existing state boards of engineering examiners have united in a "National Council of State Boards of Engineering Examiners," which has already made noteworthy accomplishment in unifying practice, raising the standard of qualifications required of licensed engineers, and establishing an official system of reciprocity between the states. Practicing licensed engineers meeting a formal higher standard of qualifications, about equal to the requirements of the American Society of Civil Engineers for associate members, can secure from their own state boards "reciprocity certificates" which are recognized in the other states in the association for licensing without formal examination.

Engineers' license laws interfere materially with the work of many of our older, well established engineers, especially in the case of those who practice in several states, and probably the majority of older engineers would still at present personally prefer freedom from licenses. Our older engineers recognize, however, that the engineers' license law movement is bound to extend throughout the country, and for this reason our great national engineering societies are coming to coöperate in the shaping of new and the improvement of existing license laws.

The American Society of Civil Engineers now has a standing committee on engineers' license laws and plans a license law committee in every state of resident members of the society, the central committee to head the whole organization.

Already the society's standing committee on engineers' license laws has conferred with the National Council of State Boards of Engineering Examiners and upon request has taken the lead in framing a suggested uniform engineers' license law, which, after revision by representatives of the founder societies and the council of examining boards, has been published in pamphlet form by the American Society of Civil Engineers. The great advantages of uniformity in our state engineers' license laws are manifest.

It seems certain that the continued development and stricter enforcement of engineers' license laws will have an important effect upon engineering education. The outcome may be practically to exclude non-graduates of engineering colleges from engineering practice and to establish accredited lists of engineering colleges in every state, each of which colleges must meet standard qualification requirements set by state authority. In effect, accredited engineering colleges will then be in some degree official state educational agencies, whether or not state supported.

The vital relation of engineering to the great mechanic arts industries of the several states amply justifies official cognizance and official recognition of the standards and other qualifications of accredited engineering colleges.

Outline of the History of Professional Codes of Ethics

For untold ages theology, medicine and law were recognized as the only "learned professions," each an exclusive calling, confined to an organized body of learned men who "professed" to have high, special, learned qualifications and who vowed devotion to high ideals in their calling.

In theology the vows of the ministry are to God and have never been reduced to set form accepted by rival sects.

In medicine, the oath of Hippocrates dates back to 400 years before the Christian era. Strict medical codes of ethics have long prevailed. The code of medical ethics of the American Medical Association is formulated in detail and is enforced by numerous state and county medical societies as well as by the national organization.

In law, the oath of admission to the bar requires each law novitiate to vow devotion to high ideals of legal practice. The Canons of Professional Ethics and the Canons of Judicial Ethics of the American Bar Association are accepted in America as our legal codes of ethics, which all lawyers are obligated to obey and all bars and courts are obligated to enforce.

Engineering has now won recognition as a "learned profession," and teaching is striving for professional recognition.

The profession of teaching has not yet adopted any general code of teaching ethics, though such codes have been studied and to some extent formulated by authors * and committees of teachers' associations.†

In ancient times, architecture and engineering were united in one profession, and they still are very closely related and associ-

* *Teaching Profession and Practice,* A. R. Brubacher, The Century Co., N. Y., 1927.

† Pp. 290–295 of Brubacher.

ated. The Roman Architect-Engineer Vitruvius, first century B.C., included chapters on water supply, military engines and machines in his book on architecture, and gave a description of leveling instruments. The ideals of Roman architect-engineers may be judged by his words.*

> "Moral philosophy will teach the architect to be above meanness in his dealings, and to avoid arrogance; and will make him just, compliant and faithful to his employer; and, what is of the highest importance, it will prevent avarice gaining an ascendency over him; for he should not be occupied with the thoughts of filling his coffers, nor with the desire of grasping everything in the shape of gain, but, by the gravity of his manners, and a good character, should be careful to preserve his dignity."

Another Roman surveyor, engineer, soldier and public official was Frontinus, who wrote a treatise† on the water supply of Rome at about A.D. 100. Frontinus was *Curator Aquarum* (Director of Water Supply) under the reform administration of Emperor Nerva Augustus and his book shows that he held high ideals of service. He says:

> "* * * and inasmuch as I am moved not only to devote diligency, but even love to any matter confided to my care, be it on account of inborn zeal, or by reason of faithfulness in office; and inasmuch as Nerva Augustus, * * * has now conferred upon me the duties of water commissioner (of water works superintendent, curator aquarum), duties contributing partly to the convenience, partly to the health, even to the safety of the city, and from olden time exercised by the most distinguished citizens; I therefore consider it to be the first and most important thing to be done, as has always been one of my fundamental principles in other affairs, to learn thoroughly what it is that I have undertaken.
>
> "There is indeed no better foundation for any business; nor can it in any other way be determined what is to be done, and what omitted; nor is there for a fair-minded man so debasing a course as to perform the duties of an office intrusted to him according to the directions of assistants: a course, however, which must be followed, whenever an inexperienced official takes refuge in the practical knowledge of his assistants; whose services though necessary for rendering help should nevertheless be only a sort of hand and tool of the principal in charge."

Francis Bacon, A.D. 1561–1626, though not an engineer, was so eminent and so potent an agent in advancing that deductive sci-

* See translation by Joseph Gwilt; an English architect, 1874.

† See translation by Clemens Herschel, Boston, 1899.

ence based on experimental research which is so characteristic of engineering that his ideals of professional obligations are of special interest. Says Bacon:

> "I hold every man a debtor to his profession; from the which as men of course do seek to receive countenance and profit, so ought they of duty to endeavor themselves by way of amends to be a help and ornament thereto."

The code of ethics of the American Institute of Architects is in force in the United States, and antedates all other engineering codes of ethics.

Engineering codes of ethics have been adopted by a number of great national engineering societies, apparently the first of which in America was the Canadian Society of Civil Engineers (now the Engineering Institute of Canada), in 1896. This code was revised in 1914.

The American Institute of Consulting Engineers, Inc., adopted a code of ethics in 1911.

The American Society of Civil Engineers adopted a code of ethics in 1914, which has since been expanded and supplemented by a code of professional practice, adopted in 1927.

The American Society of Mechanical Engineers adopted a code of professional practice in 1914.

The American Institute of Electrical Engineers adopted a code of principles of professional conduct in 1914.

The Western Society of Engineers adopted in 1917 a "code of ethics" which is in reality a statement of the general principles on which a formal code ought to be based.

The American Association of Engineers adopted in 1919 a code of ethics, and in the interests of uniformity has adopted the code of practice of the American Society of Civil Engineers.

There has been some discussion of the desirability of a single engineering code of ethics or practice, adopted by all the great national engineering societies; such a universal engineering code is a possibility of the future.

Professional Ethics and Professional Honor

There is a distinction between professional ethics and professional honor. The professional obligations of engineers include both.

The word *ethics* is derived from the Greek *ethos*,—character.

> "*Ethics* is the science of the ideal human character." *
>
> *Honor* means "fame, credit, good name, reputation." *
>
> "Honor thus carried with it the notion of social obligation, and in societies having a caste organization, as in feudal so-

* *Webster's Dictionary,* 1889 edition.

cieties, it often implies primarily a strict observance of caste obligations, and in particular of the obligation not to bring discredit upon persons of the same caste." *

The artificial code of honor of feudal days is worn out and discarded, but engineers are under obligation to cherish an equally intense and more fine sense of chivalric honor, forbidding their bringing discredit upon their profession, and calling for personal sacrifice to whatever extent required in rendering high engineering service to their clients and to the public.

"Say, what is honor? 'Tis the finest sense
Of justice which the human mind can frame,
Intent each lurking fraility to disclaim,
And guard the way of life from all offense
Suffered or done." †

The Principles of Professional Ethics

A careful study of the codes of engineering ethics and practice will show that they are based upon the highest principles of honor and justice. They demand that every member of the profession of engineering shall constantly maintain

"A nice sense of what is right, just and true; with a course of life corresponding thereto." ‡

The ethical obligations of the engineer fall mainly in six classes, as follows: §

1. *The obligations of the engineer to his client:* to whom he owes competent service, loyalty, honesty, courtesy and fairness.

2. *The obligations of the engineer to himself.* It is his duty to make the most of his ability and other qualifications; to demand respect and fair remuneration; to maintain health, virtue and justified self respect and self confidence; to gain friends, and keep them; a family, and guard and cherish it always.

3. *The obligations of the engineer to the public.* It is treason for the engineer to betray the public in any way. It is the duty of the engineer to be a good citizen as well as a good engineer, taking part in public affairs at all times, and interesting himself especially in all public questions of an engineering character.

4. *The obligations of the engineer to contractors,* to whom he owes strict justice and fairness.

5. *The obligations of the engineer to his fellow engineers.* The engineer must treat other engineers as professional brothers, main-

* *Webster's Dictionary,* 1889 edition.

† Wordsworth.

‡ *Webster's Dictionary,* 1889 edition.

§ *Engineering Ethics,* Anson Marston, Purdue Engineering Review, Vol. 19, No. 4, May, 1923.

taining in all his relations with them the fairest terms of courtesy and square dealing.

6. *The obligations of the engineer to his profession.* The engineer must subscribe to engineering journals; must join local, state and national engineering societies; must promote the advancement of engineering education; must bear himself as a loyal member of the great professional fraternity.

THE ENFORCEMENT OF ENGINEERING CODES OF ETHICS AND PRACTICE

Codes of engineering ethics are of little value unless they are observed faithfully, in spirit as well as in letter, and by practically all members of the profession. Such observance may be voluntary or enforced.

Undoubtedly the vast majority of engineers voluntarily will observe engineering codes adopted formally by their national societies or established by tradition and custom. In every profession, however, there is always an unworthy minority, willing to injure the public and their professional brothers by stooping to unethical practices unless restrained by fear of retribution.

The enforcement of engineering codes of ethics should begin in the engineering college, by maintaining manly discipline and by educating engineering students in professional codes and practices.

Enforcement is continued when the engineer makes application for admission to that membership in local, state or national engineers' clubs and societies without which no present day engineer can hope to get far in his profession. Applications for admission to engineering societies are scrutinized with increasing strictness. The American Society of Civil Engineers publishes and distributes to its entire membership the detailed record of every candidate for admission or for promotion to higher grade, with request for information from every member as to any known reason for disbarment from entrance.

Young engineers should be forewarned while still in college that their college records and the opinions of their fellow engineers are sure to come to light in this future ordeal. If young engineers could realize how unworthy acts may reappear to daunt them long years after supposedly buried in the forgotten past no sacrifice would be thought too great, no extreme of care too scrupulous in guarding their engineering honor.

The engineering societies provide official methods for filing and receiving charges of professional misconduct by members and for expulsion or other disciplinary action if necessary.

The great national engineering societies and some others now maintain standing committees on professional conduct, specially

charged with the duty of investigating member infractions of the professional codes of ethics. Recommendations are made by the committees to the boards of direction of the societies as to what action should be taken in each case. The work of professional conduct committees is arduous. In their consideration of individual cases, precedents are rapidly being established, and we may soon expect special society publications presenting the official codes of ethics accompanied by a body of rulings and interpretations in typical individual cases.

ENGINEERS' FEES AND SALARIES

The professional obligations of the engineer include his duty to demand respect for himself and fair remuneration for his services. These are due to himself, to his fellow engineers and to the engineering profession, which will be lowered in esteem and in quality of service if its services are cheapened. A large proportion of the charges against engineers of professional misconduct are caused by real or imagined cutting of prices below those maintained by self-respecting competitors. A large proportion of present-day engineers are employed on the salary basis by the public or by corporations. Engineers' salaries should be commensurate with the values of their services.

Engineering societies are now concerning themselves more than ever before with establishing scales of minimum engineering fees and salaries.

Such scales apply only to *minimum* fees and salaries. "* * * While all men and some engineers may have been created equal; the service of such engineers to their clients cannot by any possibility be considered to be equal." The value of the service of the outstanding engineer "frequently entitles him to greatly increased remuneration above that which can be considered in any scale of recommended fees for services of engineers as a body." *

The American Society of Civil Engineers has a standing committee on engineers' fees, and another on salaries. A tentative report by the committee on fees appears in *Proceedings* for September, 1929. A valuable paper by the chairman of the committee on engineers' salaries appears in *Proceedings* for March, 1930.

The American Association of Engineers published in 1929 a valuable pamphlet on "How to Employ and Use Services of Practicing Engineers," which contains recommendations for minimum engineering fees.

* *Report of Committee on Fees,* A. S. C. E., Sept. Proceedings, 1929.

ENGINEERING STUDENT CODES OF ETHICS

The writer has already indicated in this lecture his belief that engineering colleges ought systematically to educate their engineering students in professional ethics and practices. He now wishes to suggest that one effective means of accomplishing this purpose would be to encourage engineering students to formulate and adopt for themselves a "Code of Engineering Students' Ethics."

Engineering students should be treated like young men, not like adolescent boys. Their standards of ethics and honor might be much higher if based on formal codes developed and adopted by themselves. Practitioners representing the various engineering societies maintaining student chapters at the engineering colleges should assist in the development and self-enforcement of codes of engineering students' ethics.

The following is a quotation from an address on engineering ethics in 1923 by the writer to the engineering seniors of Purdue University:

> "The future of the engineering profession during the next half century depends upon you young men, just about to enter its ranks, rather than upon us older men, who find it so hard to change our attitude of mind as new questions arise in the onward progress of engineering.
>
> "I wish I could somehow make you really comprehend the overwhelming importance of engineering ethics to you.
>
> "Be honest. Honesty is absolutely fundamental in all professions, but especially so in engineering, where vast financial operations often are directed by members of the profession who have not been trained in financial guile. Cheating in college work is dishonesty. There is no room anywhere in the engineering profession for any man who has any dishonest streak anywhere in his soul.
>
> "Keep absolutely clean from all vices. The engineer must be of good repute among all men. Vice is a form of dishonesty, dishonesty to one's own soul. Vice undermines health. Success in engineering requires a strong, clean body as well as a strong clean mind. Vice enslaves. The engineer must be free.
>
> "Do your college work well. Honesty requires that no engineer shall undertake work for which he is not qualified. It is possible that sometimes you might succeed in cheating your engineering faculty, but you can never cheat engineering science. The laws are immutable and unbeatable.
>
> "Be true to yourselves. Every engineer owes it to himself to make the utmost possible out of himself.
>
> "Be true to your client. In undertaking work for him

you obligate yourself to render him true, faithful and competent service, and to guard his interests.

"Be true to the public and to your country. Be a good citizen as well as a good engineer. Vote at every election. Take a good citizen's part in politics. Render true and efficient public service, whenever called upon, and always take part in shaping wise public decisions on all engineering phases of public affairs.

"Be true to your obligations to the engineering profession. It is a fraternity in which you are to become a brother. Treat every engineer as a brother engineer, but place the interests of the profession above those of any man, even yourself.

"You owe to the profession, to yourself and even to your client (who otherwise will cheapen your advice) to charge for your services just what they really are worth. You should seek a competence, if only as a matter of self-respect and of the good repute of the engineering profession. Yet you should not be avaricious."

The Ethics of Engineering Faculties

The writer wishes to close this address with some general observations on the professional ethics of engineering professors and deans, realizing that he is venturing on dangerous ground.

First, on the ethics of their work in educating engineering students, both professors and deans have pressing obligations, more important than they often realize, to put their teaching and their other educational work on the highest plane of ability, professional attainment, scholarship, fairness, courtesy and sympathy. They should acquaint themselves with their individual students and constantly strive to teach and to inspire by precept and example, in and out of classes. After more than thirty-eight years of engineering college work, I am amazed and daunted by the reverence with which the average engineering alumnus regards his old professor. There is no proper place in engineering faculties for any man except those of highest fundamental manhood qualifications, added to professional engineering and teaching attainments of the highest order.

Second, on the ethics of their relations with each other and to their colleges, engineering professors and deans should hold to the same high ideals of professional brotherhood as are called for in codes of engineering ethics. Fairness and courtesy must be especially characteristic of engineering teachers. The dean should promote the professional advancement of every member of his faculty, even if he thereby loses good men, and he should try his best to secure adequate reward for all who render high service, yet he should have the courage to part company with slothful or in-

competent teachers. Administrative organization should be such as to place initiative and responsibility on every member of the faculty. Due academic freedom to teach and freedom to learn must be maintained in engineering colleges, yet the engineering faculty should be much more than a mere number of individuals, however able. A faculty cannot accomplish its best without effective coöperative effort.

There are many special relations between professors and other professors, professors and deans, professors and general college authorities, which might well be put into a somewhat formal statement of principles, worked out jointly, to the great advantage of higher education.

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

At the Columbus meeting, June 19, 1929, Descriptive Geometry was defined by the Division of Engineering Drawing as: "The study of the theory of a universal means of expression; it is a grammar of the graphical language." The division further agreed that the purpose of this subject include the development of the power of visualizing objects, of analyzing objects into their geometrical elements, of determining the geometrical relations between the elements, and of representing these elements in drawings in their true geometrical relations.

It is claimed for Descriptive Geometry that this subject is the only one which teaches the student to visualize thoroughly, to represent accurately, and to *think* logically.

It is interesting to note the studies now being conducted by Dr. Clair V. Mann reveal the fact that engineers of the present day are of the opinion that the power to visualize is of great importance—well-nigh indispensable to engineers—and that the power is particularly indispensable to the type of engineer whose work is of a creative nature. The trait is not so necessary for the average engineer who may be engaged in routine work. These engineers believe that the power to visualize is capable of development, likewise that there are no tests which measure the quality. Opinions indicate that of college courses which develop the quality, descriptive geometry is outstanding, with mechanical drawing and machine design close seconds. Kinematics, graphic statics, and physics are assigned much less importance, and chemistry is rated as of small value in developing the trait.

Engineers on the whole are possessed of a high degree of imagination when it comes to the reading of books and in envisaging faces and features of persons not present. The form of visualization most common among engineers is quite clearly that type of visualization corresponding to vision with the eye. In order, after the type corresponding to vision, would be the types corresponding to feeling, sense of temperature, hearing, smelling, kinesthetics, and tasting. Since taste and smell are infrequently used in design work, these answers seem to indicate that the development of the power to visualize is a matter of training; at least that it is capable of very large modification through training and experience.

Dr. Mann's conclusion from the whole study of this opinion is that the power to visualize is a trait of such value in engineering that it is highly worthwhile to develop it in the engineering student. Before scientific answers can be given to the question as to whether any particular course or college training in general develops the trait, there must be constructed scientific tests which will measure the quality, not only in latent form but in the form of increments. The development of such tests is now under way in Dr. Mann's laboratory with promise of considerable success.

NEW MEMBERS

BOND, GEORGE W., Assistant Professor of Chemistry, South Dakota School of Mines, Rapid City, S. D. E. D. Dake, C. G. Watson.

BROWN, WILSON F., Associate Professor of Chemical Engineering, Kansas State College, Manhattan, Kansas. R. A. Seaton, A. J. Mack.

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GARLAND, CLYNE F., Assistant Professor of Mechanical Engineering, University of California, Berkeley, Calif. H. B. Langille, B. F. Raber.

HILL, ARTHUR M., Instructor in Mechanical Engineering, Tulane University, New Orleans, La. D. S. Anderson, W. B. Gregory.

KARSTEN, ANDREW, Professor of Chemistry, South Dakota School of Mines, Rapid City, S. D. C. G. Watson, E. D. Duke.

MERRILL, GEORGE A., Director, California School of Mechanic Arts, San Francisco, Calif. F. L. Bishop, Nell McKenry.

PECK, JOHN S., Assistant Engineer of Tests, Columbia University, New York City. J. C. Rathbun, A. H. Beyer.

PRICE, LEONARD C., Research Associate Professor of Mechanical Engineering, University of Arkansas, Fayetteville, Ark. W. N. Gladson, W. R. Spencer.

RAW, RUTH M., Instructor in English, University of Akron, Akron, Ohio. Sada A. Harbarger, Fred E. Ayer.

RICE, ROBERT B., Associate Professor of Mechanical Engineering, Newark College of Engineering, Newark, N. J. A. R. Cullimore, J. A. Brooks.

RICHMOND, ADDISON E., Instructor in Civil Engineering, Howard University, Washington, D. C. Darnley Howard, L. K. Dorning.

SCHEVE, CARL J., Instructor in Civil Engineering, University of Colorado, Boulder, Colo. C. L. Echel, H. J. Gilkey.

SHELDON, DAWSON C., Associate Professor of Mathematics, Clemson Agricultural College, Clemson College, S. C. D. H. Shenk, B. E. Fernow.

WALKING, WALTER, Instructor in Electrical Engineering, South Dakota School of Mines, Rapid City, S. D. E. E. Clark, C. G. Watson.

WALTON, GRAHAM, Instructor in Civil Engineering, South Dakota School of Mines, Rapid City, S. D. C. G. Watson, E. E. Clark.

A COMMUNICATION FROM THE AMERICAN SOCIETY OF CIVIL ENGINEERS

Dear Mr. Bishop: You will doubtless be interested in the following resolution adopted by the Board of Direction at its meeting on January 19, 1931:

> "Adequate professional training in actual engineering practice is essential, in addition to university training, as part of the qualifications of engineering teachers, and is entitled to due recognition. While approving the continuing development now under way of graduate work in engineering leading to advanced degrees, including the Ph.D. degree, attempts by any college or university association to demand Ph.D degrees in general branches as part of the requirements for the engineering professors in accredited colleges is disapproved."

Yours very truly,

GEORGE T. SEABURY,
Secretary.

COLLEGE NOTES

Massachusetts Institute of Technology.—After a number of years of trial on a smaller scale, the comprehensive examination for senior honors students in the Department of Electrical Engineering has acquired increased status and enlarged opportunity for effectiveness and influence. By recent vote of the faculty the usual second term senior year examinations and quizzes have been entirely waived for these students in favor of a comprehensive examination, for which a two-week period has been set aside near the end of the year.

The comprehensive examination will be originated and administered by outside examiners invited from other educational institutions and from industry, in collaboration with deputed members of the Institute staff. It will search into the entire field of study of each honor student, not merely by means of a variety of isolated questions but largely by means of questions and problems in themselves more or less comprehensive. It is hoped that the comprehensive examination will serve not only as a measure of achievement for these students, but primarily as an influence upon their attitude toward study during the whole undergraduate period.

A six-weeks Textile Course for textile executives and research directors, begins February 13. This course will cover design of textile testing laboratories, conditioning apparatus, preparation of textile specimens, thread counting devices, cord testing machines, fabric testing machines, special tensile testing instruments, and instruments for measuring crimp, effect of corkscrew in plied yarns, and other special properties of fabrics. It also includes a series of lectures on textile microscopy.

Professor Wilhelm Blaschke, of the University of Hamburg, delivered a group of lectures during February on selected topics in "Differential Geometry," under the auspices of the mathematics department.

Another Rhodes Scholarship has been awarded to an Institute graduate, Mr. Morris Shaffer, who graduated last year from the Department of Biology and Public Health, and is at present an assistant on the instructive staff. Next autumn he will enter Oriel College, Oxford University, where under the provisions of the Rhodes Scholarship he will have the opportunity to study for three years.

McGill University.—A movement has been set on foot for the purpose of establishing a memorial to the late Dr. Henry Martyn MacKay, Professor of Civil Engineering from 1907, and Dean of the Faculty of Applied Science from 1923 until his death in October last. The Committee in charge of the matter, having in mind the brilliant scholarly attainments of Dean MacKay, and his keen appreciation of sound learning, have decided that a memorial in the form of scholarships open to undergraduates in the Faculty of Applied Science would be most appropriate. The members of the Faculty, many of whom have been intimately associated with the late Dean over a long period, have unanimously endorsed the proposal as eminently fitting.

The **University of the City of Toledo** opened its second semester in its beautiful buildings on West Bancroft Street, Tuesday, February 10. The buildings, the 114 acre campus and building equipment were provided out of the $2,850,000 bond issue voted by the citizens of Toledo.

The beautiful stone exteriors of both University Hall and the Field House give little indication of the immensity and completeness of the interiors.

University Hall is a 337-room building of Collegiate Gothic Architecture with a 200-foot tower. Included are 66 class rooms, 50 laboratories and shops, 4 lecture and conference rooms, 30 rooms devoted to preparation and supplies, 15 closets, 7 rest and social rooms, 4 rooms devoted to cafeterias and kitchens, 6 rooms for student activities, 7 rooms for library purposes. Many vaults, storage

rooms, closets and rooms for miscellaneous purposes have also been provided.

In one wing of the building five large chemistry laboratories are provided and private laboratories have been arranged for research and experimental work by faculty members. Laboratories have been provided for pharmacy, biology, histology, botany and zoology. One large science lecture room with a seating capacity for 250 is also provided. One of the novel features of this room is the rolling demonstration tables for the instructors. Back of a sliding blackboard at the front of the room is a preparation room where other instructors may set up their tables for succeeding lectures while one group is assembled. This allows for almost continuous use of the room.

In another wing of the building laboratories and class rooms are provided for all work in engineering, physics and astronomy. There is a lecture room with seating capacity for 100 and laboratories for hydraulics, machine shop, mechanical engineering, civil engineering, electrical engineering, materials testing, physics, astronomy, engineering drawing, machine design, blue print, model and storage rooms.

BOOK REVIEWS

Electrical Equipment. By T. C. Lloyd, of Ohio State University and Antioch College. Published by John Wiley & Sons. Price $3.50.

The problem of presenting modern power equipment, together with their costs and applications, has been solved very effectively by the author. This book is divided into eighteen chapters with a list of problems as an appendix covering the subject matter.

The book opens with a description of electrical systems in use today. Power plant circuits are covered including calculation of bus bar spacing, switching, circuit breakers and switching control. Typical switchboard diagrams are shown with illustrations for each type. Meters of all classes including ammeters, voltmeters, watt-hourmeters, demand and recording meters, are classified and dealt with at some length. Generators, both A.C. and D.C.; transformers, motors, batteries receive consideration as to construction, characteristics, choices of applications and like features. Cost curves are presented for the various machines which would be useful in practice.

The author has gone to considerable work in dealing with Illumination and Electric Heating. Tables are given for present stand-

ards for illumination of interiors; outdoor lighting as parking zones, boxing arenas, etc.; spacing of outlets; coefficient of utilization and other important items. Following the method used in other chapters of the book, Electric Heating is first classified. Specific problems are taken up for mass and space heating. Tables are presented for resistance heating. Different types of furnaces and their control are given.

The latter chapters of the book are devoted to Transmission and Distribution, Rectification of alternating currents, Protection, Power bills, Power factor and Engineering Economics. In the latter chapter, costs, interests, present worth, vestances, units costs are defined and practical solutions and formulas are included.

This book can be used with profit as a reference book for any one interested in this subject and as a textbook for a general course in Electrical Equipment.

R. W. A.

Electricity: A Study of First Principles. By ELMER E. BURNS, Instructor in Physics, Austin High School, Chicago. Published by D. Van Nostrand Company, Inc. 235 pages. Price $1.75.

This book contains twelve chapters treating the first principles of electricity from the physicists viewpoint with the application always in view. The appendix contains wire tables, physical properties of many of the materials used in electricity and conversion tables.

During and at the end of each chapter there are several problems designed to clinch the principles set forth in the text matter. At the end of each chapter there is a set of pertinent questions on the text.

The author demonstrates the principles set forth in each chapter by numerous examples mathematically worked out and also by numerous cuts and photographs.

This book should find its largest application with students in trade schools or students taking science in high schools. The chapters come in logical sequence from the point of view of the electrical engineer.

P. E. R.

EDWARD CHARLES ELLIOTT, PH D , LL D ,
President of Purdue University.

PURDUE UNIVERSITY

By GEORGE W. MUNRO

Professor of Thermodynamics

Purdue University is located in West Lafayette, Indiana, which is sixty miles northwest of Indianapolis, the capital of the state. The two cities, Lafayette (26,000) and West Lafayette (5,000), are located on opposite sides of the Wabash River at a point which was once the head of navigation of that stream, the University being on the high level land somewhat back from the flood plain.

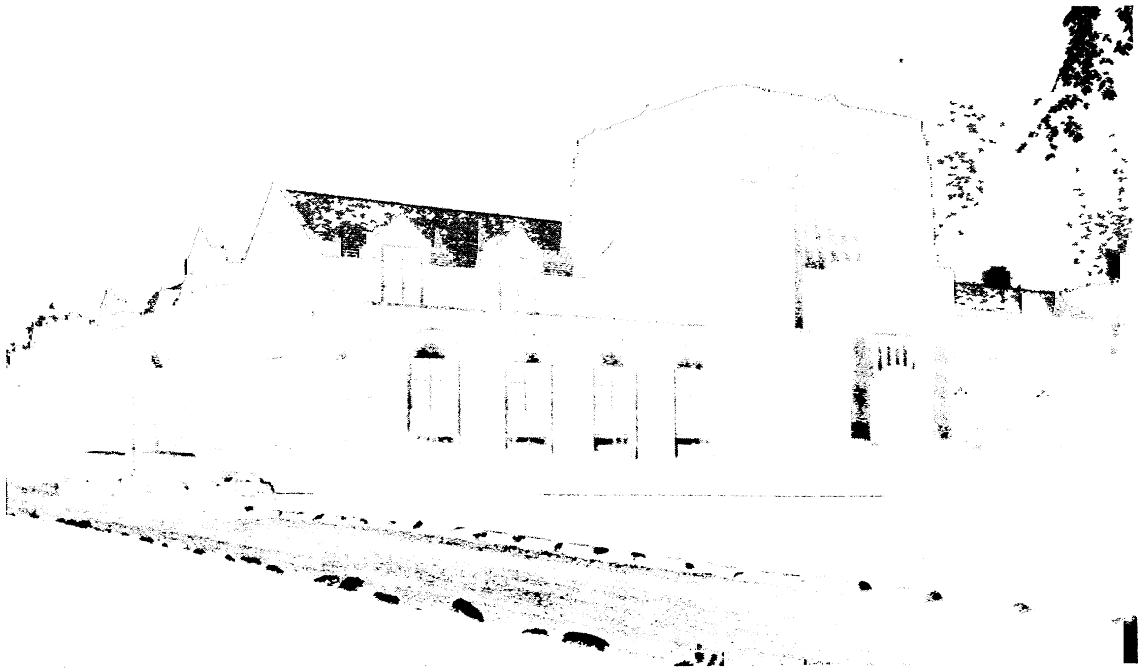
Two miles below the city is the site of Fort Ouiatanon, the first white settlement in Indiana (1720) and seven miles northeast is the Tippecanoe Battle Field, now a state park, where Harrison defeated the Indians under the "Prophet," brother of Tecumseh, in 1811.

Purdue University is the Land Grant College of Indiana, being established under the Morrill Act of 1862, the provisions of which were accepted by the state in 1865. The University was named in honor of John Purdue who gave 100 acres of land and $150,000 in money, a benefaction of first magnitude in its day and place. The principal buildings of the School of Agriculture are located on the land given by Mr. Purdue.

During its early days, Purdue University passed through more than the usual amount of turmoil and tribulation. Organized in 1872, it opened its doors for students two years later and by 1884 was under its fourth president; had been disrupted once by faculty dissensions; had suffered from fraternity controversy fought bitterly through faculty, courts and legislature; and had failed to secure state appropriations from the legislature in 1883. State Support was again withheld in 1887. In spite of these handicaps, the institution progressed and by 1888 four year courses in agriculture and in mechanical, civil and electrical engineering were established.

During the "Gay Nineties" Purdue developed rapidly both in engineering and as a whole; this period seeing the completion of the electrical engineering building, the locomotive testing plant and the mechanical engineering laboratories and shops.

It is now organized in eight "Schools," Agriculture, Civil, Chemical, Electrical and Mechanical Engineering, Home Eco-



Purdue Memorial Union Building,
Headquarters of S. P. E. E. and Meeting Place of Divisional Sessions.

nomics, Pharmacy, Science and the Graduate School; each under an administrative Dean except the four engineering schools which are under the single Dean of Engineering. Degrees are also given in Forestry, Industrial Education and Physical Education.

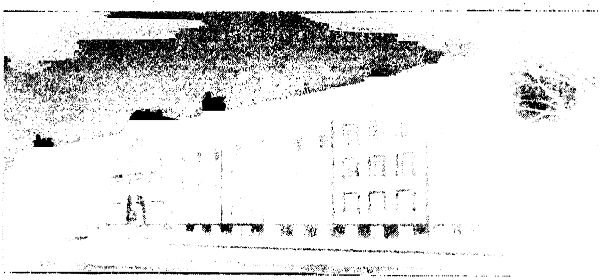
The health of the students is protected by an organized Student Health Service, while the Dean of Women and the Dean of Men head the student personal welfare services.

The 115-acre campus of Purdue University is located on high level ground almost at the edge of the vast rich prairie which extends without break to the Missouri River. Foresight in ground development has provided beautiful hedge, lawn and tree effects, while the campus itself is restfully level. The proximity of the Wabash and Tippecanoe Rivers and the Wildcat and Wea creeks provide much broken, even rugged country, within a few minutes drive of the university grounds.

Close to the campus the university is developing a system of six dormitories for men, two units now being complete and occupied. Plans are ready and ground will soon be broken for a modern system of residential halls for women nearby. A 65-acre recreation field containing the Ross-Ade Stadium is conveniently at hand, while an ample airport, recently acquired, gives opportunity for satisfactory development of a strong aeronautical division.

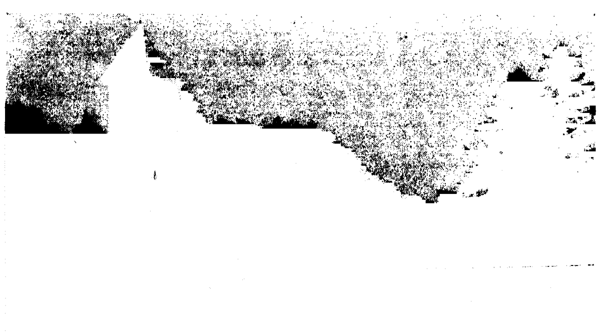
The School of Agriculture, the Agricultural Experiment Station and the Agricultural Extension Division function cooperatively under the common leadership of the Dean of the School of Agriculture. Use is made of 1,250 acres of owned land immediately in the vicinity of the University and 1,450 acres located in various parts of the state. Through the agricultural division Purdue has made notable contributions to the solution of rural problems both physical and social. Outstanding are those connected with the control of rusts, blights and other plant diseases, the preservation and transporting of dairy products, the development of disease resisting strains of wheat and maize, the development of the economics of stock feeding, the profitable preparation of farm products for the market and the control of insect pests.

Pharmacy in Indiana has received a long delayed recognition with the completion of a new and commodious building to house the School of Pharmacy at Purdue University. Besides instruction in the four-year course the School of Pharmacy maintains the university dispensary, which fills, free of charge for students, the prescriptions issued by the student health service. A pharmacy garden for growing medicinal plants is a prized possession of the School of Pharmacy.



Franklin Levering Cary Memorial Halls.
Two Fireproof Dormitories Containing 150 and 115 Rooms will be Used to House Part of the S. P. E. E. Delegates and Visitors.

Eliza Fowler Hall and Library,
Union Building in the Distance. General Meetings will be held in Eliza Fowler Hall.



Glimpse of the Campus—Heavelon Hall.
(Mechanical Engineering, Chemical Engineering and Hydraulic Laboratories.)

Home Economics was separated from the School of Science in 1926. In adddition to the laboratories for foods and textiles, it operates a residential practice house for seniors, a large cafeteria and a child development laboratory.

The School of Science gives instruction in science, mathematics, and the subjects classed as the Humanities. It thus unifies the instruction in English, mathematics, physics, chemistry, biology, history, economics, education and modern language, and continues instruction to graduation of students majoring in those subjects.

The Graduate School, only recently organized as a separate division, coordinates the facilities for graduate study and research and oversees the programs and progress of all students doing graduate work.

The Schools of Engineering which enroll about two thirds of the students at Purdue University, will be described in a separate article in an early issue of the Journal.

In the first semester of 1930–31, Purdue registered 4,550 students classified as follows:

Undergraduates:			
Agriculture		391	
Engineering		2,777	
Civil	538		
Chemical	391		
Electrical	764		
Mechanical	1,084		
Home Economics		434	
Pharmacy		101	
Science		480	
Industrial Education		25	
Physical Education		100	
Total undergraduates			4,308
Graduate School			242
Total in Residence			4,550

From the trying eighties when the President of the Board of Trustees, Mr. C. B. Stuart, pledged his personal fortune that the school the legislature forgot might carry on, to the present when the University is the recipient of a recreation field, several farms, a permanent surveying camp and an airport in rapid succession from its present President of the Board, Mr. David E. Ross, Purdue has had faithful and devoted friends with vision, both in and out of the official family. It is quite impossible in this short article, to mention either their names or their benefactions.

GRADUATE WORK IN ENGINEERING IN NEW ENGLAND COLLEGES *

By CHESTER L. DAWES
Harvard University

As an introduction to the subject of Graduate Work in Engineering in New England Colleges, I am presenting first a general background to graduate work in engineering in American engineering schools as it exists today.

I believe that anyone engaged in teaching engineering will agree that the present standard period of four years for an undergraduate program in engineering is entirely inadequate. We teachers feel pressure from all sides. For example, we are told that we do not devote sufficient time to cultural studies so that our graduates tend to become self-contained, and narrow-minded; and are unable to enjoy to the fullest extent the finer things of life.

We are told that the time devoted to the subject of human relationships is entirely inadequate; our graduates are lacking entirely in ability to deal with personnel and labor problems.

Other employers tell us that our graduates have inadequate knowledge of basic scientific principles, that is of the so-called fundamentals of engineering.

We also hear occasionally that more emphasis should be given to certain special branches of engineering owing to their present day importance. I believe, however, that the more enlightened industries now ask only for sound basic scientific training, they themselves preferring to supply the specialized training, which their particular industry requires.

We also hear many lesser suggestions regarding possible improvements in the content of our curricula. We all appreciate the fact that the foregoing criticisms have some justification. It is true that the student engineer should be given sufficient cultural studies to give him breadth of vision and to give a greater number of points of contact with the men of other interests whom he is certain to meet both professionally and socially.

It is true that the human and labor problems in industry were never more acute than they are today, when machinery and mass production are displacing manual labor at a rate which is considered

* Presented at the meeting of the New England Section, S. P. E. E., Dartmouth College, November 1, 1931.

by many to be alarming. Hence, some preparation by students to meet such problems is very desirable.

It is inevitable that the design of machinery and engineering structures should attain greater and greater refinement as the knowledge of the physical, chemical, and electrical reactions which occur within them become better known; also the intensive research which is now being conducted on such a wide scale is continually resulting in new scientific discoveries that are applicable to engineering designs. Such factors require that our students have a much sounder, and I may say broader, grasp of mathematics, physics, and chemistry and the possibilities of their application to engineering problems, than was formerly required.

It is also desirable and helpful to give students work in some specialized branches of engineering, since the application to engineering problems of the basic scientific principles which they have been taught in the abstract, is illustrated, and nothing fixes such principles better than their concrete applications. The number of such specialized courses that can be included in an undergraduate curriculum is very limited on account of the small amount of time available; also, as a rule it is not possible to prepare the average undergraduate for any specialized branch of engineering, since he usually does not know definitely the field of work which he will enter, until he is about to graduate, and sometimes not even then.

The foregoing is given to illustrate the fact that both the employers and the teachers of engineering students believe that our four year undergraduate programs in themselves do not produce well rounded prospective engineers, nor do they develop sufficiently the latent qualities that are inherent in the students. In fact, I believe that in the limited period of four years, none of us expects to graduate a well developed engineer in the sense that the professional schools of recognized standing graduate physicians, lawyers, and dentists. The best that we can hope to accomplish in a four-year undergraduate program is to give the student a small and insufficient amount of cultural background, a sound but inadequate grounding in basic scientific principles and a very limited number of their concrete applications, and what is, I believe, of most importance to give an ambition or an impetus which will impel him by his own efforts to continue to expand and develop himself further in cultural and humanistic activities as well as in his own professional field.

The inadequacy of the four-year program in engineering [1] is recognized by both students and teachers, and where it is possible to do so, engineering students should be recommended to take an arts degree before registering in an engineering school, and thus

[1] See Society for Promotion of Engineering Education. Report of the Investigation of Engineering Education, Vol. I, page 133.

complete the requirements for the engineering degree in an additional two years. In some institutions, the course in the college of liberal arts may be so selected that the student receives his arts degree in four and his engineering degree a year later. This procedure is admirable, not only in liberalizing the training of the engineer and thus overcoming some of the disadvantages of the four-year engineering program, but also in giving the engineering student campus life and contacts that are either difficult or impossible for him to obtain in the engineering schools alone. Engineering graduates who have obtained their training under these conditions not only show the advantages of this type of training but almost without exception recommend it to those who are able to devote to study the extra time which is necessary. However, due to the long-established custom of a four-year program, the importance to many engineering students of beginning productive work as soon as possible, usually for financial reasons, and the fact that several industries give engineering graduates further opportunity to study for advanced degrees, it is possible to interest but a small proportion of the total number of students in this type of program, meritorious though it may be.

Although the programs of study of such students may consist entirely of undergraduate engineering courses, it appears to be the general custom to classify them as graduate students and so far as enrollment is concerned, to make no discrimination between them and those graduate students whose program may consist partially or entirely of advanced or graduate courses. In most New England engineering schools, these graduates are awarded the same degree as is given to the undergraduates on the satisfactory completion of their programs. At Harvard, recognition is taken of the broader background of such students and they are awarded a higher degree than the undergraduates even though both may have completed satisfactorily the same program of engineering studies. Likewise, Dartmouth awards the degree of Civil Engineer (which is equivalent to a Master's degree) upon the satisfactory completion of the program in engineering. All candidates for this engineering degree must first however have obtained a Bachelor's degree. At the Massachusetts Institute of Technology this class of students, who are candidates for the S.B. degree, are enrolled as undergraduates; those who are candidates for higher degrees are enrolled as graduates. The minimum requirement for the degree of Master of Science with or without field of designation is that 75 per cent. of the subjects taken shall be primarily for graduates. (See Appendix for detailed practice of each institution.)

This type of graduate student constitutes a considerable proportion of the graduate engineering students of our New England

colleges, but since several of the schools in their enrollment data do not discriminate between them and graduates who are taking for the most part graduate courses, it is not possible to enumerate the exact number. In this paper such students are with one exception classified as graduate students; some institutions, however, do discriminate between them and the graduate student whose program consists for the most part of graduate work, and the numbers of each type for such institutions may be found in the Appendix.

In most engineering schools there are students of mediocre ability who show little or no promise of becoming engineers of outstanding attainment, but who manage just to "get by." For them, perhaps, the four-year program has developed all their latent ability, although in some cases, this may be debatable. On the other hand, there are almost always students who by their scholastic attainments, their analytical ability, their personality, and their determination, give every promise of becoming outstanding figures in the engineering profession. I believe that such men should be given every incentive and aid to continue their engineering training by graduate work in an academic atmosphere and under academic auspices.

Experience shows that during the time which they devote to graduate work they will develop a much broader outlook, will acquire a much keener analytical ability and more serious and mature demeanor than can possibly be hoped for in a student who has just completed his undergraduate requirements for a bachelor's degree. In other words, students who have completed one or more years of graduate work are more nearly a finished educational product in the same sense as are doctors, lawyers, and dentists from professional schools of recognized standing. Moreover, both the engineering schools and industry recognize this, for, at the present time at least, the demand for such men both for teaching positions and for technical positions in industry far exceeds the supply.

For example, it has often been emphasized that if the standard of the teachers of engineering is to be maintained and even raised, it will be necessary to attract and recruit young men not only of ability and promise but of attainment as well. These qualities, I believe, are best developed and tested by graduate work in an academic institution. This belief has been recently substantiated by one of the leading engineering institutions of New England in the appointment of two young scientists and holders of doctor's degrees, one as its president and the other as the head of its department of physics.

At the moment, industry is not able to obtain the necessary number of men who are sufficiently well trained to solve its more intricate and pressing research problems, as well as to solve its

business and personnel problems. It recognizes the value of graduate training in engineering by taking so large a proportion of our graduate students that practically none remain for teaching and research positions.

Thus engineering teaching and industry will greatly benefit if graduate work can be further encouraged and the number of graduate students of promise be increased. However, graduate work, particularly in New England engineering schools, is not limited to recent graduates. Many teachers of engineering are finding it well worth while to pursue further study; some for example, attend summer schools; others take special summer work with industrial organizations; and a number devote a leave of absence or a sabbatical year to graduate work at some engineering school, preferably not their own. This plan is particularly advantageous to teachers, in that they not only acquire additional training and knowledge from the courses which they take, and also perhaps an advanced degree, but in addition they are able to get an insight into the organization and methods of an engineering school not their own. This gives them inspiration and ideas that may be advantageous for their own school. For similar reasons a number of engineering teachers from other countries take graduate work in American engineering schools.

Engineering graduates who have for some time been active in industry frequently find that the problems they are attempting to solve require some specialized knowledge or the application of some newly discovered laws of science with which they are not entirely familiar, or which are not readily accessible to them. This is particularly true at the present time when science is making so many startling discoveries, particularly in laws relating, for example, to atomic structure and to hydrodynamics. Such engineers frequently find it advantageous to return for a period to some engineering school and take work of an advanced nature usually under some recognized specialist. Similarly, engineers from other countries either come here of themselves or are sent by their governments or employers to take graduate work in engineering in American colleges.

Thus we find that the body of our graduate engineering students consists of recent graduates who may become teachers or who may enter industry; teachers taking advanced work toward further academic degrees; and men from industry seeking further academic training.

In spite of the inducements that industry may offer the promising student who has just obtained his first bachelor's degree, I believe that it is advantageous for him to continue with graduate work at an engineering school if he is financially able to do so. The academic atmosphere of study and research cannot be duplicated in industry

where the prevailing atmosphere is production, high-speed machinery and commercial activity.

For graduate students the cost of instruction must necessarily exceed by a considerable amount the cost per undergraduate student, since graduates are fewer in number, are given more individual attention, and usually require more or less extended facilities for research. Furthermore, graduate work is most properly given by specialists or men who have attained distinction in some particular field. For these reasons it seems generally agreed that graduate work should be undertaken only by those institutions which have adequate facilities in both teaching personnel and equipment. Those schools which are not as yet in a position to offer substantial graduate work should, and for the most part are concentrating on their undergraduate work, and should be commended for so doing.

This situation is well stated in the following quotation from the Report of the S. P. E. E. Board of Investigation and Coördination (Vol. I, page 117).

"It is desirable that resident graduate work for advanced degrees should be undertaken only by engineering colleges with notable teachers and exceptional facilities; that a program of additional undergraduate studies should not be considered as graduate work leading to an advanced degree, and that the several institutions engaged in graduate work should emphasize distinctive fields of effort according to their special advantages of personnel, location and equipment; that the graduate student should seek out the best qualified master in his field of special interest and, in most instances, should migrate to some institution other than the one attended as an undergraduate for the sake of the added breadth; and that financial inducements to prospective graduate students should be offered only to men of distinct promise."

And on page 139:

"It is advised that a considerable number of engineering colleges confine their efforts to a sound undergraduate program and pursue the practice of directing their graduates to other institutions for advanced work."

Inasmuch as the total number of undergraduates in engineering schools is several times the number of graduates and as the educational problem involved in imparting a sound engineering training in the short period of four years is tremendously difficult, it seems only rational that the greater proportion of engineering schools should concentrate on the problem of better training for the undergraduate. This also seems to be the prevailing sentiment among the Engineering Schools of New England. Sentiments to this effect are expressed by some of the engineering teachers of our New Eng-

land Colleges in statements from them which appear in the latter part of this paper.

New England Colleges

There are thirteen colleges in New England offering courses in engineering. These are listed in Table I. Since New England is generally recognized as the early seat of learning in the United States, it is only natural that its engineering schools should at least have their proportionate number of graduate students. I have attempted to ascertain this proportion for the past year or two but the latest statistics which I have been able to obtain are those of the United States Bureau of Education for 1924–25. At that time 81 institutions out of a total of 151 offered graduate work in engineering. It was estimated that there were about 1,000 graduate students in engineering of all kinds, including those on part time, although only 707 were regularly enrolled. Most of these were candidates for the master's degree.

Five hundred and seventy-two degrees were conferred of which only eight were doctor's degrees, the remainder being master's degrees or the equivalent. Of the foregoing enrollment of engineering graduates, 258 were from New England Colleges.

Hence it appears that 36 per cent or over one third of the graduate students of the country were at that time enrolled in New England Colleges. Similar statistics for the year 1925–26 which are the latest available give for 143 engineering institutions in the United States the total number of postgraduate students as 1,114 and the total number of students working for their first degree as 54,337. This gives 1 to 49 as a ratio of graduate to undergraduate students for that year.

Since that time, the number of graduate students in the United States has increased rapidly, it being estimated that at the present time there are more than 1,600. Simultaneously, too, the number of graduate students in New England Colleges has also increased rapidly for there is now a total number of 595 as shown in Table I, and incidentally, this gives 37 per cent as the ratio of the graduate students in New England to the number in the country as a whole. At the present time the ratio of graduate engineering students to the number of engineering students working for their first degree for the entire country is estimated to be approximately 1 to 12, so that the proportion of graduate to undergraduate students in New England colleges is three and one quarter times as great as it is for the country as a whole.

In this paper it is not the intention to discuss in any detail the practices and methods of administering graduate work in the individual New England Colleges, but rather to present a general

TABLE I

DATA RELATING TO GRADUATES AND UNDERGRADUATES IN NEW ENGLAND ENGINEERING SCHOOLS—OCT. 1930

	Undergraduates						Graduates							
	Graduate work	Mechanical	Electrical	Civil	Other Branches	Total Undergraduates	Mechanical	Electrical	Civil	Other Branches	From own Undergraduates	Outside	Total Graduates	Ratio of Graduates to Undergraduates
Brown University	yes	(Unclassified)				167	(Unclassified)						3	0.018
Dartmouth College	sp.			7		7			14		14		14	2.0
Harvard Eng'g School	yes	59	53	30	50	192	14	30	9	19	10	62	72	0.375
University of Maine	yes	155	141	137	136	569			1	2	3		3	0.005
Mass. Inst. of Tech.	yes	326	410	182	1,220	2,138	41	101	36	225	136	267	403	0.188
Univ. of New Hampshire	yes	49	57	47	76	*400				5	5		5	0.022
Northeastern University	no	370	509	412	420	1,711		15		20			35	0.020
Norwich University	no		65	70	29	164								
Rhode Island State	no	56	36	54	136	282								
Tufts College	no	75	75	150	30	330								
University of Vermont	no	33	47	51	0	131	1						1	0.008
Worcester Poly. Inst.	yes	173	122	91	263	649	3	7	1	2	11	2	13	0.020
Yale University	yes	34	26	37	169	266	11	20	4	11	9	37	46	0.173
Totals	7 yes 5 no. 1 sp.	1,330	1,541	1,268	2,529	7,006	70	173	65	284			595	0.085

* 171 unclassified (freshmen) included.

view of conditions as they now exist together with some comparative data. These data are tabulated in Table I, and are offered for purposes of information and as a possible basis for discussion. Obviously, the individuals connected with any particular school can best describe in more detail the conditions which exist in their own particular institution, together with their experiences with graduate work. Opportunity for doing this will be given in the discussion which follows this presentation.

Appendix

Statements Relating to the Individual Engineering Schools

There are a few statements from representatives of some of the individual schools which amplify or describe in some detail their particular situations. These are submitted as follows:

As is indicated in Table I, Brown University does not attempt except in the fourth year to discriminate between the different fields of engineering. This is explained by Prof. A. E. Watson of the Electrical Engineering Department as follows:

"Since about 1914 Brown University has not attempted to make early specialization in the three lines of engineering, but to lay the fundamentals, along with an admixture of cultural studies, and in the senior year only to begin the several diversions. For the first two years the courses of instruction are identical for all three lines; in the junior year there is opportunity for a slight selection, but in the senior year the student may spend about all his time in the particular line which he has decided. Our experience in this procedure meets with the approval of a large number of our graduates and directors of the various industries into which the men enter.

"Although graduate instruction has been conducted here for about 40 years under the direction of its graduate department with its special dean, only just now has the 'Graduate School' been definitely established and recognized. A limited amount of graduate study has always been conducted by the division of engineering leading to the degree of Master of Science, but now with the enlarged plans we intend to prepare for activity that will be in keeping with the rest of the institution.

"You will recollect that Engineering here is not a separate department, but is a portion of the academic college. To dodge the suspicion we call it a 'Division' not a 'Department.'"

Dartmouth College occupies a unique position in regard to graduate work in engineering. The situation is expressed in the S. P. E. E. Report (loc. cit.), p. 134. "There is therefore but one

institution, *i.e.* Dartmouth, other than certain coöperative schools, where the first degree in engineering cannot be gained in a four-year period." In addition Dean Marsden submits the following:

"The Answer to Question No. 2 (Do you give graduate work in Engineering?) depends upon the definition of graduate work. I should rather say the Thayer School presents professional work or is a professional school rather than a graduate school. This because of the fact that although we do not present work in research or advanced theory, as is the case in some institutions, no man is admitted to the work of the final year in the Thayer School unless he holds a Bachelor's degree. The fact that it requires five years to earn the degree of Civil Engineer at Dartmouth is in part due to the fact that during the three years of undergraduate work a part of the schedule is made up of the so-called cultural studies, such as Literature, Art, Social Sciences, and so forth.

"I am afraid therefore that you will have to use your own judgment as to the proper answer which I should give to Question 2."

Of the total number, 72, of engineering graduates in the Harvard Engineering School, thirteen have arts degrees and are taking essentially undergraduate engineering courses for their next degree. After having completed satisfactorily the required program in engineering, this class of graduate students is awarded a Master's degree in engineering without designation of field, in recognition of their work in engineering, taken in conjunction with the requirements which they have met to obtain their first degree. Of the 72 graduate students, 6 have returned from industry for further graduate work and 5 more are teachers of engineering who are working for an advanced engineering degree.

The University of Maine requires that graduate students pursue graduate work in a major department or subject in which the candidate has already completed the equivalent of at least two years of undergraduate study. In graduate work, the engineering school specializes in Pulp and Paper, Electric Power Transmission, Sanitary Engineering and Concrete Design.

Dr. H. M. Goodwin, Dean of Graduate Students at the Massachusetts Institute of Technology, submits the following:

Total registration of graduate students in Science and Engineering who are working for higher degress—538.

Number with Bachelors' Degrees from M.I.T.—201.

Number with Bachelors' Degrees from other colleges in the United States—298.

Number with Degrees from foreign universities—39.

The registration thus shows that this year 37.4 per cent of our graduate students are from the Institute, 55.4 per cent from other colleges in the United States and 7.2 per cent from foreign countries. One hundred forty-nine colleges, universities and technical schools are represented, of which twenty-four are outside of the United States. The rather large increase in registration over the last year is due chiefly to a larger percentage of students coming to the Institute from other institutions. In addition to the above students who are working for higher degrees, there are also registered one hundred eight college graduates who are working for the S.B. Degree. These students are regarded and classified as *undergraduate students* as they are expected to complete the curriculum of one of the regular undergraduate courses under the same conditions as other undergraduates. Only those students with Bachelors' Degrees who are definitely working towards a higher degree without taking the Institute's S.B. Degree on the way, are classified as "Graduate Students."

There is, therefore, a fundamental distinction between the classification and requirements of students with college degrees according as they intend to pursue work leading to the Institute's Bachelor's Degree, or to the Master's or Doctor's Degree. No discrimination is made in classifying as "graduate students" those whose college preparation is such that they must take more or less undergraduate work as preparation for graduate work and those who are able to enter at once upon their advanced work. The former require, of course, a longer period of residence to meet the requirements for the degree, but if they have degrees from recognized institutions and their credentials are such that they are accepted as prospective candidates for a higher degree by the department in which they wish to enter, they are classified as "graduate students" irrespective of the time it may take them to qualify for the degree.

The minimum requirement for the degree of Master of Science, whether taken with or without specification of the field of science or engineering, is that 75 per cent of the subjects (units) taken must be chosen from courses primarily for graduates, that is, more advanced in character than those which are required in any undergraduate curriculum. The remaining 25 per cent of the work may be chosen either from similar courses or from subjects of senior grade, that is, those open to both graduates and to undergraduates. In other words, the Master's Degree at the Institute is based chiefly on work more advanced in character than that given to undergraduates. A thesis is in all cases required.

In graduate work the University of New Hampshire specializes in Inorganic, Analytical and Organic Chemistry.

Prof. W. Lincoln Smith, Head of the Electrical Engineering Department at Northeastern University submits the following:

"Northeastern has felt that at least for the present it would be far better to hold to the programs of undergraduate work. It appears that there is ample opportunity available for graduate study in other institutions in this vicinity. While we do not offer graduate work, a limited amount of special research work is carried on by members of the Faculty. Our attention is rather guiding suitable men toward research with graduate work under the various corporations' supervising plans."

Tufts College submits the following statement:

"At present Tufts is not equipped to offer graduate work in engineering but there is a possibility that developments in research carried on here may lead to an opportunity for some graduate courses.

"I believe it better for any student to change to another institution after four years under one faculty, and that it is profitable to do graduate work at those institutions which have the greatest resources for such work."

At Worcester Polytechnic Institute, graduate students taking undergraduate work often prefer to be listed as undergraduates when working for B.S. degrees. All thirteen graduate students already have the B.S. degree.

Yale specializes in graduate work as follows:

"In Civil Engineering—structural, highways, sanitary engineering, and hydraulics.

"In Mechanical Engineering—Thermodynamics, power engineering, particularly under the latter, steam and internal combustion engines, automotive, marine power, machine design.

"In Electrical Engineering—power transmission, machinery, communication.

"In Industrial Engineering—personnel and industrial relations.

"In Metallurgy—Physical metallurgy.

"In Chemical Engineering—applications of physical chemistry to industrial problems."

Conclusions

It would seem therefore that since both teaching and industry require engineers in increasing numbers, who need broader and more thorough training than is possible in an undergraduate program, graduate work in engineering schools is certain to assume greater

and greater importance. As the Engineering Schools in New England are at least on a par with those elsewhere in the country as regards the quality of graduate work which they offer, and the proportion of graduate students is approximately three and one-quarter times as large as in the country as a whole, it would appear that the New England schools should assume leadership in strengthening their graduate departments and in encouraging and aiding promising undergraduates to continue with graduate work.

Discussion by Dean H. E. Clifford

Professor Dawes has presented an admirable paper, brief and yet comprehensive. With his point of view I am in hearty agreement. For a number of years past many of us in the teaching profession have realized the ever-increasing difficulty of preparing adequately our students to meet effectively the complex situation which confronts them on graduation. The enormous growth which has taken place in those fundamental sciences on which engineering rests has called for either omitting what many of us regard as essential parts of the field of science in which engineering students should be trained or else what is much worse a lack of thoroughness resulting from the attempt to include the entire field.

More and more it becomes clear that the standard time of four years is inadequate for the proper preparation of engineering students to practice their profession. The tradition of the four year program is much like that of the five cent fare. It is a tradition from which it seems extremely difficult to depart. But just as the five cent fare has been superseded finally, so will the four year program be superseded when our educators exhibit the courage of their convictions.

To achieve success in satisfying measure, an engineer must possess both technical ability and the attainments of a broadly educated man. The professional study of engineering is necessarily concentrated, intense, and in part highly specialized. For this reason alone it should be preceded by preparation designed not only to train the student in mathematics and those sciences specifically required as a basis for technical instruction, but also to give him an adequate cultural background before he devotes himself exclusively to his professional education. The preparation afforded by a program of study leading to a bachelor's degree meets these needs if the subjects have been wisely chosen. Consequently the A.B. or S.B. degree will in time, and I believe in no distant time, be set as a general requirement for enrollment in professional schools conducted on a graduate basis. In saying this I am not unmindful of the fact that there will always be the exceptional student who will be given the exceptional opportunity.

It is my belief that many students, who as undergraduates obtain their training for the engineering profession, lose much of the happiness and joy of college life which is almost the right of a student of undergraduate age. The constant pressure to get work done, the excessive amount of laboratory work, the drudgery, all tend to make a man look upon these years as a chore of life, whereas they should be among the happiest in a man's whole life. By increasing the time beyond the four year period for the preparation for active practice of his profession, the average student will get a background which will enable him to much better adapt himself to an environment and that ability is in general sadly lacking among scientific men. I believe that such subjects as history, language, literature, economics will all help him to remove this lack, a lack which is greatly to his detriment. As new fields of engineering develop they take the practicing engineer into regions and into human contacts that are entirely strange. Today the engineer often becomes a man of affairs, a business executive, a diplomat, a politician, an envoy to foreign countries, a molder of public opinion. He has need for the broadest education and sooner or later our engineering colleges must recognize this fact. And sooner or later also our students of engineering will recognize it and are going to get this broad training in those engineering schools which rest their intensive technical preparation for engineering practice on the advantages to be obtained in the A.B. degree.

Naturally it will not be possible and perhaps not desirable that all our engineering colleges should require a bachelor's degree for admission. It will be quite impossible for those institutions which are dependent upon tuition fees to take this position; but where the institution is well endowed, I believe it would be a great step forward in the educational development of this country if there could be established in various parts of the United States at least a few engineering colleges which are conducted on a strictly graduate basis.

Hermon L. Slobin: "I believe that if an institution be truly a university, it is absolutely necessary for the good of the undergraduate colleges that the faculty should have a mastery of their subjects, and resources far beyond the knowledge of texts. The mastery of subjects can be achieved best by preparing to give advanced courses and undertaking investigations. In general, the existence of graduate work—or a Graduate School—small though it be—serves notice to the faculty, and hence to the students, that the university demands growth and achievement, and I am certain that its existence will have a salutary effect in maintaining a higher standard in the undergraduate colleges.

"I see no reason why the superior students should not be

encouraged, or even subsidized by scholarships, so that they may avail themselves of graduate instruction. I do not see why we should not devote at least a portion of our institutional interests on behalf of the superior students, upon whom, ultimately, is dependent the advancement of our civilization.

"It is my belief that no department can possibly render its best service in the undergraduate colleges if it has not the qualifications to meet the needs for at least the Master's Degree in the Graduate School. I grant that the work for the doctorate should be offered only by those departments and those institutions that can make a contribution of sufficient value and importance truly to merit the advanced degree."

R. R. Marsden: "The analysis of graduate work in the New England Colleges by Professor Dawes is a real and definite contribution to the Society and we are all indebted to him for the thoughtful consideration which he has given to its preparation.

"In view of the fact that Dartmouth is the only institution, aside from the coöperative schools, where the first degree in engineering requires more than four years, the following comments may not be amiss.

"Thayer School was founded by General Thayer, himself an honor student in the classics at Dartmouth, and later Superintendent of West Point. His ideal was for a professional school based upon a course in college as broad as possible in order to fit its graduates to be worthy members of a profession as noble and honorable as any in the world. Some twenty years later President Tucker announced the broad policy in his statement, 'It is always and everywhere the function of the College to give liberal education, beyond which and out of which the process of specialization may go in any direction and to any extent. The College must continually adjust itself to make proper connection with every kind of specialized work, not to do it.' Still later, President Hopkins said: 'The policy of the Thayer School of Civil Engineering is based upon the theory that the purpose of an education is to give a man breadth and depth in his knowledge. In the field of Civil Engineering, therefore, the educated engineer, under the policy of the School, must first of all have acquired the general culture which it is the purpose of a College education to give, and must then have superimposed upon this, specialized knowledge in regard to the scope of the field of engineering and the various facts which have to do with basic principles essential to a Civil Engineer. In other words, it is the purpose of the School to give to the College educated man knowledge of the fundamental theory and practice of engineering, but at the same time to induce him to see the relationship of engineering to life as a whole.'

"In pursuance of these policies the following program was developed. Two years' work in strictly engineering subjects follows the satisfactory completion of a three year course in College, during which time the fundamental preparatory subjects are cleared up together with a considerable amount of work in the so-called cultural studies. Parenthetically, I should like to voice a definite and decided objection to the too prevalent idea that scientific and engineering subjects have no cultural value. If on the completion of three years of satisfactory work the student is admitted to the Thayer School of Civil Engineering, at the end of the fourth year he is awarded a Bachelor's degree from Dartmouth College. Upon the satisfactory completion of the work of the fifth year he is awarded the degree of Civil Engineer.

"There are very definite advantages to us in such a program. For one thing the problem of elimination does not occur as applicants are required to have maintained better than average grades during the preliminary three years. Another effect of this requirement is to reduce the number of admissions so that small classes have resulted.

"During the earlier years of the School six years were required to obtain the engineering degree but for the past forty years it has been possible to complete the required work in five years.

"Our complete agreement with the conclusions reached by Professor Dawes is indicated by the fact that for such men as propose to enter the teaching profession and for those who wish to specialize, we urge graduate work at some institution properly qualified both as to faculty and facilities."

ARTHUR E. NORTON: As a supplement to Professor Dawes's paper, I would call attention to the importance of graduate work in so-called "Applied Mechanics," a subject which underlies the whole problem of more rational mechanical design of machines and structures. In order to make clear what I have in mind, I will list briefly some of the topics which come under this heading:

(1) *Dynamics of Rigid Body during Acceleration.*
(2) *Theory of Mechanical Vibrations.*
  a. Balancing of reciprocating engines.
  b. Torsional vibrations of shafts.
  c. Critical speed of shafts.
  d. Effect of vibrations on foundations.
  e. Noise prevention.

(3) *Elasticity.*
  a. Combined stresses on oblique planes of crank shafts.
  b. Thick cylinders and self hooping of guns.
  c. Stresses in high speed rotors due to centrifugal force.
  d. Stress concentration around holes, slots, and fillets.

(4) *Hydrodynamics.*
  a. Design and lubrication of bearings.
  b. Long pipe lines for transmission of oil or other fluids.
  c. Centrifugal pumps.

(5) *Aerodynamics.*
  a. Aeronautic problems.
  b. Ventilation of generators.
  c. Fans and blowers.

These subjects are forced upon us because of the ever-increasing size, speed and precision of machines. The purchaser wants more power in less space, and demands quiet operation as well as efficiency. This tendency is not confined to mechanical engineering but is one of the major features in the electrical industry. An engineer of one of the large electrical companies has recently said that "nearly 90 per cent of the field trouble in electrical apparatus is *mechanical* in nature. The high cost of material and labor makes these troubles intolerable, especially since modern competition renders it impossible to charge field development to the customer."

We have progressed beyond the time when statics and kinematics alone were sufficient for machine design. The consideration of elasticity and vibrations has already become a major problem, little understood by most designers. The technical literature on these subjects has grown to tremendous proportions in Germany and England but American mechanical engineers have been interested in them only recently. At the present time, however, there is a demand by industry for a reasonable number of high-grade American engineers with an interest in Applied Mechanics.

The first concrete evidence of this was in 1921 when Mr. George M. Eaton, then Chief Mechanical Engineer of the Westinghouse Company, founded the Mechanical Design School of that company to meet the deficiency as he saw it. This school has been most significant but I will not go into its history in detail, since it has been well covered in the proceedings of our Society. However, two features of it I wish to emphasize. First, the school was *born of necessity*, due to the scarcity of American technical graduates with sufficient interest and fundamental background in mechanics. Second, its graduates are *not used exclusively in the research laboratory* but are often drafted off by the power and engineering departments. This shows that men with superior analytical training are finding

their place in the daily work of industry. Other industries are noting the same deficiency and are glad to take Engineering graduates who are proficient in this field.

I agree with Professor Dawes that the undergraduate program is so short and the number of fundamental subjects so great that graduate work for a few of the best men is the only way to raise the standards of engineering education to meet new demands. The only question is whether the schools or the industries should undertake the burden of this higher training. My answer is that certain schools must undertake it at least to the extent of the equivalent of the Master's degree, except in topics which are highly specialized.

The field of Applied Mechanics is not too specialized but is basic for many branches of research and design. It gives good general training in differential equations, periodic functions, graphical integration, boundary constants and other mathematical technique which are used in all branches of science and engineering. It offers many illustrations of unique applications of physics; for example, the use of polarized light and soap films for study of secondary stresses. It requires reading the classical writers on physics to give a picture of the historical development of the physical sciences and to provide a background for facing new problems.

Even though some industries can train their own men in this subject, it is to their own interest in the long run to foster it in the schools because it is there that the young men first learn that they have some analytical ability and find out what their tastes and desires are. Further, it is in the long run safer for the student to get some start on his advanced work before committing himself to the specialized work of one company.

Our New England group will perhaps be interested to learn that the Harvard Engineering School has begun to meet this situation by offering a course on "Vibration Problems in Engineering." This subject is taught mainly by two visiting lecturers, Mr. J. Ormondroyd of the Westinghouse Company, manager of their experimental division and their consultant in the development of the Diesel engine as applied to Diesel-electric locomotives, and Mr. A. L. Kimball of the General Electric Company, an authority on vibration damping. The interest of the students exceeds our expectations.

We are also giving an advanced course in "Hydrodynamics as applied to Lubrication and Bearings," and another on "Stresses in High Speed Rotors."

To this group of New England teachers I suggest that you watch for students with analytical ability and inform them of the opportunities of further study and of ultimate pleasurable employment in this field of Applied Mechanics which lies at the very center of the engineering profession. Tell them that the designing engineer is

not a pencil pusher on the drafting board, but that he visits the laboratory and shop and is likely to be sent out over the country on unusual errands of investigation or advice.

As Professor Dawes points out, the engineering schools of New England have as the major job the training of boys as undergraduates, and have done much in the last few years to make our graduates better all around men. If we have failed at all, it would seem to me that we have not done as much as we could to select the exceptional boy and stimulate him to go into more advanced work. Certainly the field of Applied Mechanics and Engineering Design at the present time holds many attractions for the capable young mechanical engineer.

H. P. Hammond: "The four-year undergraduate curriculum is pretty firmly established as the norm in engineering colleges. While there are a few notable exceptions, this practice is nearly universal, and the indications are that it will so continue for some time to come. That being the case, the rapidly increasing demand of industry and practice for a proportion of engineering graduates with a more extended training, particularly in the fundamental sciences, seems to point definitely to the need of more extensive provisions for graduate work in our schools. The increase in attention devoted to graduate work is in fact one of the pronounced trends in engineering education at present, as Professor Dawes' paper admirably points out. From 1925 to 1930 the number of graduate students of engineering has practically doubled, and at present about one student in each five or six who receives his undergraduate degree pursues advanced academic work in one way or another.

"One of the most interesting developments in this connection has been the institution at a number of colleges of programs of part-time graduate instruction. The University of Pittsburgh, the University of Pennsylvania, Massachusetts Institute of Technology, Union College, and the Polytechnic Institute of Brooklyn, are among the institutions that have recently entered this field of work. The aggregate enrollment of part-time graduate students in these schools is approximately 900, or a very considerable fraction of all of the graduate students of engineering of the country. The programs offered differ somewhat, and time does not permit of more than a brief discussion of one of them—that with which I am most familiar—the evening school work of the Brooklyn Polytechnic Institute.

"A limited amount of graduate work in engineering has been offered at the Polytechnic for a number of years, but three years ago the courses offered were considerably increased and are now provided in all of the major departments. The first year that the present program was instituted, 125 students registered for the

work. Last year there were 180, and this year 250 to date. Apparently the number of students who would pursue such courses is limited only by our ability to provide teachers and facilities. Graduation from a recognized engineering college whose undergraduate program is substantially equivalent to our own is insisted upon for admission. Further, a probationary period of at least a semester must elapse before the student is formally accepted as a candidate for an advanced degree. Tuition charges are fixed by courses, the total fee for the master's degree being the same as in our undergraduate curriculum, namely, $360, for the equivalent of a full year of residence work. Thirty semester hours, including a thesis, are required for the master's degree. As a rule, it will require three years of work to secure this degree and a good many students plan their programs for a period of four, or even five years. It is a rare exception that a man can secure the master's degree in two years in the evening. The programs of study are quite flexible and the student is given considerable choice in the field of work he proposes to follow. There is a strong tendency for the election of the more scientific types of studies.

"Graduate students at the Polytechnic received their first degrees from fifty-seven different institutions, of which eight are foreign institutions. The report of our Dean of Graduate Study states that 31 per cent of the students have been out of college five years or more. A very large number of industries are represented in the graduate student body, the communications companies accounting for 35, and the electric light and power companies for 49 students.

"The graduate work is carried for the most part by the members of our regular faculty but a number of lecturers are engaged on a part-time basis. We also have one visiting professor in the person of Ernst Weber, of the Technical Institute of Charlottenberg, Berlin. Professor Karapetoff, of Cornell, also gives us a certain amount of his time. One course we have offered this year for the first time may be of some interest—namely, that in bridge engineering. This course is given only to graduates who have pursued a course in advanced structures, and is intended primarily for men engaged in bridge engineering work. The lectures are delivered by a group of eleven experts in various fields, including such men as Drs. D. B. Steinman, C. W. Hudson, J. A. L. Waddell, Messrs., Alston Dana, O. E. Hovey, Charles F. Goodrich, and others.

"The establishment of this graduate program in New York City seems to meet a definite need among graduates who, while engaged in their regular professional work, desire to secure advanced study chiefly of a scientific nature."

THE 1931 SESSIONS OF THE SUMMER SCHOOL FOR ENGINEERING TEACHERS

By H. P. HAMMOND

Director of Summer Schools

For the general information of the Society membership there are printed on the following pages the staff lists and programs of the two sessions of the Summer School that will be held during the coming summer. Other points of general information are also given, chiefly for those who may be planning to attend.

The Session on Chemical Engineering

As previously announced, this session will be held at the University of Michigan beginning Monday, June 22. This opening date will permit those who attend the annual meeting of the Society at Purdue to go directly from that meeting to the summer session at Ann Arbor. The formal session of the school will close on July 9. It will be followed by a conference on July 10 and 11, under the auspices of the American Institute of Chemical Engineers, on phases of chemical engineering education other than those considered at the Summer School. On July 13, 14 and 15 the Summer School group will move to Pittsburgh for the inspection of research and industrial organizations. While at Pittsburgh the headquarters of the School will be at the Mellon Institute of Industrial Research, where opportunity will be given for the study of methods of conducting chemical engineering research enterprises. A number of visits of inspection will also be made to representative industries of the Pittsburgh district.

The headquarters of the Summer School at the University of Michigan will be at the East Engineering Building. The group will live in the Mosher-Jordan Residence Hall. This is a new and beautiful dormitory building within walking distance of the engineering buildings.

The expenses of attendance include the usual registration fee of $10, and a charge of $42.50 for room and meals for the entire period of the stay at Ann Arbor, from June 22 to July 11, inclusive Those remaining at the University for less than the entire period of the session may secure room and meals at the rate of $2.50 per day. The expenses of the inspection trip to Pittsburgh, which will be

optional for those attending, will be in addition to those already mentioned.

As in past sessions, definite provision will be made for recreation during leisure hours. The University and Ann Arbor and its vicinity provide excellent facilities for golf, tennis and other sports. There are also many summer resorts within easy motoring distance.

Staff of the Session on Chemical Engineering

Local Director of the Session: A. H. White, Professor of Chemical Engineering, University of Michigan

Secretary: W. L. McCabe, Assistant Professor of Chemical Engineering, University of Michigan

W. L. Badger, Professor of Chemical Engineering, University of Michigan

W. L. Beuschlein, Assistant Professor of Chemical Engineering, University of Washington

G. A. Bole, Research Professor of Ceramic Engineering, The Ohio State University

Charles O. Brown, Vice-President, Chemical Engineering Corporation

George Granger Brown, Professor of Chemical Engineering, University of Michigan

R. K. Brodie, Director of Manufacture and Technical Research, The Procter & Gamble Company

W. W. Buffum, Director, Chemical Foundation, Inc.

Lawrence V. Burton, Editor, "Food Industries," McGraw-Hill Publishing Company

Harry A. Curtis, Professor of Chemical Engineering, Yale University

Albert W. Davison, Professor of Chemical Engineering, Rensselaer Polytechnic Institute

Barnett F. Dodge, Associate Professor of Chemical Engineering, Yale University

John VanNostrand Dorr, President, The Dorr Company, Inc.

C. C. Furnas, Physical Chemist, U. S. Bureau of Mines

Arthur W. Hixson, Professor of Chemical Engineering, Columbia University

Ralph A. Hayward, Vice-President and General Manager, Kalamazoo Vegetable Parchment Company

Hoyt C. Hottel, Assistant Professor of Fuel and Gas Engineering, Massachusetts Institute of Technology

Zay Jeffries, Consulting Metallurgist, Aluminum Company of America

Sidney D. Kirkpatrick, Editor, Chemical & Metallurgical Engineering, McGraw-Hill Publishing Company

Warren Kendall Lewis, Professor of Chemical Engineering, Massachusetts Institute of Technology

William H. McAdams, Professor of Chemical Engineering, Massachusetts Institute of Technology

G. H. Montillon Associate Professor of Chemical Engineering, University of Minnesota

George Oenslager, Research Chemist, The B. F. Goodrich Company

H. L. Olin, Professor of Chemical Engineering, University of Iowa

John C. Olsen, Professor of Chemical Engineering, Polytechnic Institute of Brooklyn; President, American Institute of Chemical Engineers

Clifford E. Paige, President, The American Gas Association; President, Brooklyn Gas Company

L. V. Redman, Director of Research and Development, and Vice-President, Bakelite Corporation

E. S. Rothrock, Assistant Manager, Texas Chemical Company and Louisiana Chemical Company, Inc.
E. C. Sullivan, Vice Chairman, Corning Glass Works
O. R. Sweeney, Professor of Chemical Engineering, Iowa State College
R. S. Tour, Professor of Chemical Engineering, University of Cincinnati
Robert E. Wilson, Assistant to the Vice-President, Head of Development and Patent Department, Standard Oil Company (Indiana)
James R. Withrow, Professor of Chemical Engineering, The Ohio State University

Program

MONDAY, JUNE 22

2:00–4:00 P.M.	Registration	

TUESDAY, JUNE 23

8:00–10:00 A.M.	Registration	
10:00 A.M.	Greeting	President, A. H. Ruthven
	Response	H. P. Hammond
	The purpose and Function of Chemical Engineering Education	A. H. White
2:00 P.M.	The Chemical Engineering Curriculum	H. A. Curtis
7:30 P.M.	Smoker	

WEDNESDAY, JUNE 24

8:15 A.M.	The Place of Unit Operations in a Chemical Engineering Curriculum	W. K. Lewis
10:00 A.M.	The Nitrogen Situation	H. A. Curtis
1:30 P.M.	The Place of Laboratory Work in a Chemical Engineering Curriculum	W. L. Badger
2:30 P.M.	Inspection of Laboratories	

THURSDAY, JUNE 25

8:15 A.M.	Distillation	W. K. Lewis
10:00 A.M.	Petroleum Refining	R. E. Wilson
1:30 P.M.	Historical Development of Chemical Engineering	W. L. Badger

FRIDAY, JUNE 26

8:15 A.M.	Fluid Flow and Fluid Measurement	R. S. Tour
10:00 A.M.	Light Alloys	Zay Jeffries
1:30 P.M.	Discussion of Laboratory Experiment on Fluid Flow	H. L. Olin
2:15 P.M.	Discussion of Laboratory Experiment on Distillation	J. R. Withrow

SATURDAY, JUNE 27

8:15 A.M.	Heat Flow, General, Except Radiation	J. C. Olsen
10:00 A.M.	Developments in Gas Engineering	Clifford Paige
Afternoon	Recreation	

MONDAY, JUNE 29

8:15 A.M.	Gas Absorption	W. H. McAdams
10:00 A.M.	Recent Developments in Plastics	L. V. Redman
1:30 P.M.	Discussion of Laboratory Experiment on Heat Exchangers	O. R. Sweeney
2:15 P.M.	Discussion of Laboratory Experiment on Gas Absorption	W. L. Beuschlein

TUESDAY, JUNE 30

8:15 A.M.	Drying	W. H. McAdams
10:00 A.M.	The Work of the Chemical Foundation	W. W. Buffum
1:30 P.M.	Contact Sulphuric Acid	E. S. Rothrock

WEDNESDAY, JULY 1

All day trip to Ford Motor Company

THURSDAY, JULY 2

8:15 A.M.	Evaporation	W. L. Badger
10:00 A.M.	Developments in Rubber Technology	George Oenslager
1:30 P.M.	Discussion of Laboratory Experiment on Evaporation	A. W. Hixson
2:15 P.M.	Discussion of Laboratory Experiment on Drying	G. H. Montillon

FRIDAY, JULY 3

8:15 A.M.	Filtration	J. V. N. Door
10:00 A.M.	Modern Developments in the Soap and Oil Industries	R. K. Brodie
1:30 P.M.	Development in the Paper Industry	Ralph A. Hayward

SATURDAY, JULY 4

Recreation

MONDAY, JULY 6

8:15 A.M.	Thermodynamic Attack on Chemical Engineering Problem	B. F. Dodge
10:00 A.M.	Developments in Refractories	G. A. Bole
1:30 P.M.	Technology of High Pressure Reactions	C. O. Brown

TUESDAY, JULY 7

8:15 A.M.	Combustion	G. G. Brown
10:00 A.M.	Glass Manufacture	E. C. Sullivan
1:30 P.M.	Discussion of Laboratory Experiment on Filtration	A. W. Davison
2:15 P.M.	Discussion of Laboratory Experiment on Heat Balance	G. G. Brown

WEDNESDAY, JULY 8

8:15 A.M.	Radiation and High Temperature Heat Flow	H. C. Hottel
10:00 A.M.	Price Trends in the Chemical Industries	S. D. Kirkpatrick
1:30 P.M.	Discussion of Methods of Teaching Unit Operations in Class	

THURSDAY, JULY 9

8:15 A.M.	Flow of Heat to Solids	C. C. Furnas
10:00 A.M.	Recent Developments in the Food Industries	L. V. Burton
1:30 P.M.	Discussion of Methods of Teaching Unit Operations in the Laboratory	
7:00 P.M.	Banquet	

The Session on Mathematics

This session will be held at the University of Minnesota, Minneapolis, from August 24 to September 5, inclusive. This period was chosen so that members attending the Summer School may stay over for the meetings of the American Mathematical Society and the Mathematical Association of America, which will be held at the University of Minnesota beginning September 7.

The expenses of attending the mathematics session, aside from the cost of travel, will include the registration fee of $10 and a charge of $35 for room and meals for the entire period of the session. Those who desire to remain for the mathematical societies' meetings may arrange to occupy the same quarters at a charge of $3 per day. The Summer School group will be housed in Sanford Hall, one of the dormitories of the University that provides excellent facilities.

Minneapolis provides unusual opportunities for recreation. Provision is made for various sports, including golf, tennis, volley ball and swimming. Minneapolis is in the famous lakes region of Minnesota and there are many lakes and bathing beaches within the limits of the city itself. Within easy motoring distance are numerous other lakes and resorts.

Staff of the Session on Mathematics

Local Director of the Session: O. M. Leland, Dean, College of Engineering and Architecture, and the School of Chemistry, University of Minnesota

Secretary: C. A. Herrick, Associate Professor of Mathematics and Mechanics, College of Engineering and Architecture, University of Minnesota

Raymond Clare Archibald, Professor of Mathematics, Brown University

William J. Berry, Professor of Mathematics, Polytechnic Institute of Brooklyn

W. E. Brooke, Professor of Mathematics and Mechanics, University of Minnesota

Thornton C. Fry, Mathematical Research Engineer, Bell Telephone Laboratories

Melvin E. Hagerty, Dean, College of Education, Professor of Educational Psychology, University of Minnesota

E. R. Hedrick, Professor of Mathematics, University of California at Los Angeles

Edward V. Hungtington, Professor of Mechanics, Harvard University

Dunham Jackson, Professor of Mathematics, University of Minnesota

Charles N. Moore, Professor of Mathematics, University of Cincinnati

Louis O'Shaughnessy, Professor of Applied Mathematics, Virginia Polytechnic Institute

Leigh Page, Professor of Mathematical Physics, Yale University

Henry L. Rietz, Professor of Mathematics, University of Iowa

Charles S. Slichter, Dean, Graduate School, Professor of Applied Mathematics, University of Wisconsin

F. T. Spaulding, Associate Professor of Education, Harvard University
S. Timoshenko, Professor of Engineering Mechanics, University of Michigan
Warren Weaver, Professor of Mathematics, University of Wisconsin
John W. Young, Professor of Mathematics, Dartmouth College

Program

MONDAY, AUGUST 24

8:30–11:00 A.M.	Registration	
11:00 A.M.	Address of Welcome	O. M. Leland
	Response	H. P. Hammond
1:30 P.M.	The Learning Process	F. T. Spaulding
3:00 P.M.	Discussion, led by	E. R. Hedrick
7:30 P.M.	Smoker—Address by	President L. D. Coffman

TUESDAY, AUGUST 25

8:30 A.M.	Making Learning Permanent	F. T. Spaulding
10:15 A.M.	Discussion, led by	L. O'Shaughnessy
1:30 P.M.	Mathematical Aspects of the Theory of Elasticity	S. Timoshenko

WEDNESDAY, AUGUST 26

8:30 A.M.	Teaching the Fundamentals of Trigonometry	E. R. Hedrick
10:15 A.M.	Mathematical Aspects of the Theory of Vibration	S. Timoshenko
Afternoon	Recreation	

THURSDAY, AUGUST 27

8:30 A.M.	The Teacher in the Classroom	F. T. Spaulding
10:15 A.M.	Discussion, led by	L. O'Shaughnessy
1:30 P.M.	Representation of Functions by Series	Dunham Jackson

FRIDAY, AUGUST 28

8:30 A.M.	Diagnosis of Students' Difficulties	F. T. Spaulding
10:15 A.M.	College Algebra—Course Content	W. E. Brooke
1:30 P.M.	College Algebra—Teaching Problems	W. E. Brooke

SATURDAY, AUGUST 29

8:30 A.M.	Coördination of Mathematics with Related Engineering Subjects A Discussion, led by	O. M. Leland
10:15 A.M.	Mathematics of Statistics	H. L. Rietz

MONDAY, AUGUST 31

8:30 A.M.	Analytic Geometry—Course Content	W. J. Berry
10:15 A.M.	Analytic Geometry—Teaching Problems	W. J. Berry
1:30 P.M.	History of Mathematics before the Seventeenth Century	R. C. Archibald

TUESDAY, SEPTEMBER 1

8:30 A.M.	History of Mathematics after the Sixteenth Century	R. C. Archibald
10:15 A.M.	Differential Calculus—Course Content	E. V. Huntington
1:30 P.M.	Differential Calculus—Teaching the Nature of the Derivative	E. V. Huntington
3:00 P.M.	Differential Equations—Course Content for Engineering Students	Warren Weaver

WEDNESDAY, SEPTEMBER 2

8:30 A.M.	Integral Calculus—Course Content	E. V. Huntington
10:15 A.M.	Integral Calculus—Teaching Problems	E. V. Huntington
Afternoon	Recreation	

THURSDAY, SEPTEMBER 3

8:30 A.M.	The Problem of the Size of Class Sections	M. E. Haggerty
10:15 A.M.	The Problem of Adjustment between College and High School Mathematics	J. W. Young
	Discussion, led by	L. O'Shaughnessy
1:30 P.M.	Conformal Mapping	Warren Weaver

FRIDAY, SEPTEMBER 4

8:30 A.M.	Combined vs. Unit Courses in Mathematics	J. W. Young
10:15 A.M.	Mathematical Foundations of Electric Circuit Theory	T. C. Fry
1:30 P.M.	Summability of Series	Charles N. Moore

SATURDAY, SEPTEMBER 5

8:30 A.M.	Theory of Relativity	Leigh Page
10:15 A.M.	Self-Development of the Teacher of Mathematics	C. S. Slichter

Enrolment

At the time of writing (April 24) there are over 50 teachers registered for the two sessions and additional applications are coming in rapidly. It is evident that the attendance at the two sessions will be as good as in former years. Applications for admission to either session may be simply in the form of a letter stating the desire to attend, the academic title, and the institute of the applicant. This should be sent to the Director of the S. P. E. E. Summer Schools, 99 Livingston Street, Brooklyn, N. Y.

ENGINEERING AND SCIENCE *

By IRVING A. PALMER

Professor of Metallurgy, Colorado School of Mines

The word engineer is derived from an old Latin root which means to produce, to create. The word scientist, which is also of Latin origin, comes from a word which means to know. In the etymology of these terms is to be found, I think, the basic difference between the calling of the engineer and that of the scientist. The engineer is a builder, a man who assembles the raw materials and forces found in nature and so fashions and controls them as to make them useful to society. The scientist knows a great deal about some at least of these materials and forces, but does not necessarily make any practical use of his knowledge.

Let me say at the beginning that I am in no sense attempting to disparage the work of the scientist. The object of this paper is simply to point out the essential differences between engineering and science, and to suggest some of the things that, presumably, should be included in the training of an engineer.

As everyone knows, there are no two human beings who are exactly alike. Every individual is different from every other individual, in appearance, physical strength, mental ability and tastes. These characteristics are largely the products of heredity and environment. The careers of most men and women are controlled in great measure by these impulses; they do things and they express likes and dislikes because of an inward, partly subconscious urge.

Among the traits implanted in certain persons is what we call scientific curiosity—the desire to know about nature and the laws which govern its various phenomena. If the one who possesses these desires has the opportunity of gratifying them, and if he has the necessary industry, he becomes a scientist. If his thirst for knowledge is unusually keen, he will wish to scrutinize every detail of that which he investigates. And because of the tremendous area now included in the field of science, and because his tastes impel him to prefer one particular subject to any of the others, he becomes a specialist. He devotes his time to learning as much as possible about one branch of science. He may become so absorbed

* Presented at Meeting of the Colorado School of Mines Branch of the S. P. E. E., November 12, 1930.

in his investigations in his own particular line that he will almost entirely neglect the others. He may disregard or even scorn any suggestion that his researches might have a monetary value. I like the story of the scientist who was showing a party of friends through his laboratory. After explaining, with a great deal of pride, the nature of one of his long continued investigations he made the following remark: "Thank God, so far as I know, no one will ever be able to make any practical use of the results of these experiments." That, of course, is the scientific spirit raised to the *n*th power. Louis Agassiz, the famous zoölogist of Harvard, once declined an opportunity to turn his learning to commercial advantage by saying that he had no time to make money. Ernst Haeckel, the great German scientist, devoted years of patient research to the minute examination of more than six thousand different specimens of deep sea life, for the purpose of proving or disproving, I do not remember which, certain phases of the theory of evolution.

The common criticism of the pure scientist that he is not practical is, therefore, beside the point, for in most cases he is not particularly concerned about that feature of his work at all. And, as has been pointed out recently by an American essayist, the typical scientist does not consider himself, primarily, a public benefactor; that is, in conducting his researches he is not necessarily actuated by a spirit of altruism, but simply by the driving power of his thirst for knowledge. All other motives are incidental. It could be said that, in a sense, he is just as self-seeking as the rest of us, because he is merely pursuing that line of endeavor in which he finds the greatest happiness. His work gives him pleasure and contentment, which he might not have if he tried anything else. The average scientist, of course, is a good citizen. He publishes freely the results of his investigations, and is greatly pleased when they can be used in promoting the welfare of his neighbors.

What about the engineer? In the first place, he, too, must select his calling because he considers himself better fitted for that than for any other. If his work is not congenial he cannot hope to succeed. In my opinion this is almost the only point that should be considered in choosing a vocation. The popular impression that some divisions of natural science, and some branches of engineering are so much more important than others that students should be influenced thereby, is a mistaken one. As a matter of fact, no scientist or engineer is warranted in asserting that his particular calling is superior to that of anyone else in the same general class. The point that should be emphasized is this: It is more creditable to be a capable scientist, for example, than to be an inefficient engineer, just as it is better to be a good engineer than to be an indifferent scientist.

A most important distinction between the engineer and the scientist is that the former must be practical; that is, he must always have in mind the idea that whatever knowledge, scientific and otherwise, that he possesses must be used first of all in the design and construction of material things that society considers desirable. He does not pursue knowledge primarily for its own sake, but for the uses to which he can put it. He has no scruples as to receiving money for his services, and usually takes all he can get. Like the scientist, he is not necessarily of an altruistic turn of mind; he builds the things that people want. Some of the things may be of doubtful value, but that is no concern of his.

Unlike the scientist, the engineer is not a specialist; that is, he does not devote the greater part of his time to the accumulation of facts and the development of theories in one particular branch of knowledge, regardless of their relation to other branches. He takes what he can use from a great variety of sources, scientific and purely practical. He need not be an expert in any particular science, for instance, but he must know enough about each one of them to select what he needs, and then to know how to use what he has selected. To put it in the form of an epigram, the scientist knows a great deal about one subject, whereas the engineer should be moderately familiar with a number of subjects.

A good example of the relation between science and engineering is to be found in the development of the cyanide process for the extraction of gold and silver from ores. The various cyanide compounds were investigated and described by Gay-Lussac more than a hundred years ago. In 1846 the great scientist Michael Faraday discovered that metallic gold could be dissolved in a solution of potassium cyanide. But neither he nor anyone else at that time ever thought of using cyanide in the metallurgy of gold. And, had the idea been suggested to Faraday, it is probable that, like Agassiz, he would have replied that he had no time to make money. It was not until 1887, forty one years later, that three metallurgical engineers took out a patent covering the use of cyanide for the extraction of gold and silver. The process was put into practical operation at a time when it looked as if there might be a scarcity of gold. Largely as a result of the use of cyanidation the output of gold in the world quadrupled in twenty years. The cyanide process probably has had more far reaching consequences than those of any other metallurgical development that has taken place in the past half century. But without the labors of scientists like Gay-Lussac and Faraday the process never would have been heard of, and without engineers to put it into practice it never would have extracted a single ounce of metal.

The engineer and the scientist, therefore, are, in a sense, comple-

mentary to each other, except that the engineer can never use more than a very small part of what any individual scientist has to offer. In saying this I am not by any means implying that most scientific research has only academic interest. From the long range point of view every discovery in pure science may be considered as having practical value, although this value may not become apparent until many years after the date of the investigation. But at any given time the total amount of scientific data available is very much greater than the entire engineering profession could possibly put into practical application.

The field of natural science, however, is not the only source of material for the engineer. A large part of all engineering practice is based upon purely empirical data; that is, upon the results of experience. Sometimes there is no sound underlying theory whatsoever. What is often loosely referred to as theory, as exemplified by the contents of many textbooks on engineering, on examination will be found to consist largely of records of what has been accomplished in practice. In such subjects as structural and historical geology, ore dressing and pyrometallurgy the developments have taken place largely without the aid of working theories, and often in spite of them. The flotation of ores, for example, became a great industry, involving the outlay of millions of dollars of capital, before there was any satisfactory explanation of the fundamental principles of the process. J. E. Johnson, Jr., states, in one of his very excellent books on the theory and practice of iron smelting, that 99 per cent. of what is known about the operation of an iron blast furnace is empirical. An exaggeration, no doubt, but probably not far from the truth. The first chemist was introduced into the iron and steel plants of Pittsburgh less than sixty years ago. Prior to that time the metallurgical methods employed were in the control of so-called practical men.

The engineer, therefore, cannot afford to ignore the results of experience. In any process that he contemplates using, the sole criterion by which he judges it is this, Will it work? If it does work, it does not matter to him, so far as results are concerned, whether there is a satisfactory explanation of it or not.

Of course, every engineer wants to know as much as possible in regard to the theories of any process that he uses, because the more the fundamental principles are understood, the greater the saving in time and money by eliminating the wastes of the cut and try method. The flotation process, as has been stated, was developed largely without the aid of theory. If, however, a satisfactory working hypothesis in regard to the causes of flotation had been known from the beginning it would have saved millions of dollars. The latter represents the money spent for experimental work that otherwise

would have been unnecessary; the money spent for useless reagents; and the metal losses resulting from the low recoveries. On the other hand, if the mining companies had waited for the development of a generally accepted theory of flotation, before investing their capital in plants using the process, the industry never would have gotten started.

Another thing that differentiates the engineer from the scientist is that the former is, in a sense, a business man as well as a technical man. This of course is implied in what I have already said as to the nature of his work. He succeeds in this work only if he can make money for the organization or individual that employs him. If his criterion of what he designs and builds is, Will it work?, that of his employer is, Will it pay? There is no way of getting around this fundamental fact. Professor Thomas Eggleston, formerly at the Columbia School of Mines, used to define metallurgy as "the art of extracting money from ores." I have never seen a better definition.

Some years ago a young mining engineer was commissioned by a New York capitalist to look over a mine in the far West. The engineer was talented and ambitious. He spent a long time in examining carefully the property and then prepared a very elaborate report. He discussed at length the various theories in regard to the ore deposits in the district which he visited, using as many technical terms as possible; he wanted to impress his employer with the profundity of his knowledge. He then took the report back to New York and read it to the capitalist in person. When he had finished, the business man turned to the engineer and said: "Young man, your report sounds very interesting and convincing, but it contains a great many terms with which I am totally unfamiliar. What I want to know is this: In your opinion, would I be justified in putting several million dollars of my own money into this proposition?" The young engineer hesitated a moment and then said, "Yes, I think you would." "That's all I want to know," replied the capitalist, "Good afternoon."

It follows as a matter of course that an engineer should become familiar with the principles of economics and with practical business methods. Figures collected by the Society for the Promotion of Engineering Education show that more than fifty per cent of the graduates of technical schools in the United States at some time in life rise to executive positions. Those who fill these positions successfully know that it is necessary for them to be very much more than mere technologists.

A young graduate of an engineering school once told me that he never read a newspaper, and hardly ever looked into a book. He said that he had no time for such things. His case reminds me of that other young man, of opposite tastes, who boasted to his

professor that he read twelve hours a day. "My God!," replied the older man, "when do you do your thinking?" Both of these young men were lacking in a sense of proportion; they were equally unfitted for the profession of engineering, for they could never maintain a proper balance between theory and practice.

Another important distinction between the scientist and the engineer is that the former confines his activities largely to dealing with inanimate objects and forces. With him, human relations are merely incidental. All that he needs in order to be successful are industry and a thirst for knowledge. He can be eccentric, conceited, tactless, selfish, disagreeable, narrow-minded, and utterly impractical, and still be efficient in his own particular line. The engineer, however, deals not only with things but with human beings. Some of his biggest problems are in connection with what he calls human engineering. Often he finds it necessary to call upon all the tact that he can muster, and if he is conscious of possessing any of the minor failings that have just been mentioned he must do what he can to hold them in check. As he usually aspires to the holding of an executive position, he must learn to know men and to know how to handle them. The higher his station becomes the more he realizes that for him tact is greater than talent. And, from sheer necessity, he must leave more and more of the purely technical matters to his subordinates, and devote his own time mainly to human and business relations.

Charles E. Carpenter, the late president of E. F. Houghton & Co., and the brilliant editor of the house organ, "The Houghton Line," once remarked that every man in his organization drawing a salary of twenty thousand dollars a year or more had forgotten all that he ever knew about algebra. The implications are obvious.

Some years ago I was being shown through the great plant of the Ingersoll-Rand Company, at Phillipsburg, New Jersey, by one of the superintendents. After we had inspected the various manufacturing departments we came to a large well lighted room that had the appearance of a laboratory, and in which a number of men were working at desks and tables. Pointing to it my guide said, with a smile, "We call this room the 'nut shop'; it is the place where our research men conduct their investigations." He said little more than that, but I understood.

The men in that laboratory were scientists, working on special problems in a field suited to their talents, and in which, presumably, they were contented and happy. When their researches were completed they turned the results over to the engineers outside, who put the new ideas into practice and determined whether or not they had any commercial value. The scientists in the research department and the engineers in the plant could not have exchanged places.

Each group would have been failures in attempting the duties of the other.

I have devoted so much time to this discussion of definitions because there is a widespread misconception as to what engineering education really means. Even in technical schools there are experienced teachers who do not seem to understand. They conduct their classes in almost the same way as they would if they were teaching in a college of pure science or liberal arts.

The first thing that an instructor in an engineering school should realize is that the institution is attempting to steer the middle course between the pure science and liberal arts schools on the one hand, and the trade schools and business colleges on the other. He must be willing and eager to draw his material from a great many sources, without becoming obsessed by the importance of any one of them. The primary purpose of a technical school is not to turn out scientists, scholars, research men, teachers, mechanics or business men, but engineers. Consequently, the courses and the methods of instruction should be pointed in that direction.

The teachers in such schools may be divided into two general classes, the experienced engineers, and those who have had little training in the field. The members of the first group are inclined, when entering the teaching profession, to overemphasize the importance of the practical. On the other hand, the instructors with mainly an academic background, are inclined to put too much stress upon purely theoretical considerations. No one can blame the members of either group for the perfectly natural bias which they possess when beginning their teaching careers. But if, after a reasonable length of time, the two types refuse to make concessions to each other they will be deserving of criticism; for their collective teaching will become simply a hodgepodge of ill-assorted facts and theories, and their students will become oppressed by a sense of bewilderment.

" ACADEMIC-GRAPHICS "

BY EDWARD TAYLOR

Professor of Engineering Mathematics, Pomona College

All we teachers of engineering drawing or mechanical drawing or draughting—or whatever name we call it—are sure our subject is of greatest importance—that it is valuable to the famous "average" man as well as to the engineer—that it offers trainings and disciplines valuable to all educated people. We believe this thoroughly—do we have the courage of our convictions?

After many years spent as a civil and mechanical engineer the writer finds himself teaching "pre-engineering" subjects in a most "Academic" Liberal Arts College.

For some years it has been evident that the enrollment in our drawing courses was greater than the probable number of pre-engineering students in the College would warrant. This led us to fear that our work was classed as "snap" or "pipe" courses This would have been just too bad, as at times we make ourselves abnoxious by declaring that engineering schools demand more and better work from their students than is possible in a Liberal Arts College. We started to investigate, feeling that there were many instructors who would gladly tell us that we were giving courses where students got "A" with the minimum of labor or annoyance. We found no such condition.

The enrollment in the drawing courses runs; 60 per cent students interested in engineering or architecture, 20 per cent science majors, and 20 per cent English or social science majors. The majority of the non-engineering students had been put into the drawing by their major subject advisors.

Somewhat the same ideas motivate instructors and students. Physics majors seek ability to make clear, pleasing sketches and diagrams; geology majors the same plus training in projection and space perception as an aid in Crystallography. The future business magnates feel that engineering is so interwoven with modern business that it is imperative for business men to understand the drawing of the engineer and architect. Pre-dental and pre-medical students consider it training in manual control.

The desire for such specialized skills or knowledge is not uniform, but all are seeking training in neatness. A professor of English said: "I urge your course upon boys whose work is disorderly,

inexact, or messy, or who are incoherent in their thinking. A year of the work makes a great change—the exact thinking demanded by drawing leads to understanding of the need of exact thinking in general."

This universal emphasis on training in general neatness and in thinking is a surprise. It is an idea that has not been present in the teaching. The course has been presented entirely as engineering training. The work demands much thinking by the students, but the teaching has had to do with thinking about geometrical or structural relationships, not about thinking in general. Neatness is never spoken of, plates must be absolutely correct and exact; they must be free from erasures, rough lines, bad letters, etc. In other words plates must be neat, but only because each of the separate needs that makes for neatness must be satisfied.

These qualities have not been stressed. Nevertheless the work has sold itself to a third of the men in our college, doing this in large measure because of these qualities. If these qualities had been made prominent, if we had given as much thought to the 40 per cent of non-engineering students as to the engineering students, if we had varied the work to suit their needs what per cent of enrollment might we have had?

The question is broader than local results here. If in the somewhat antagonistic atmosphere of a "cultural" college with no pushing by the instructor this work can sell itself to staff and students as a desirable training, then we may be sure that drawing teachers are justified in their high opinion of the subject. Instead of telling each other that we have something good we should "tell the world." We should strive to have it made accessible not only to the engineering students but to the entire student body.

Straight, clear, accurate thinking is the real goal of all teaching.

ECONOMIC CONFERENCE FOR ENGINEERS

An economic conference for engineers will be held this summer, from August 30 through Labor Day, September 7, at the engineering camp of Stevens Institute of Technology in northern New Jersey. President Harvey N. Davis of Stevens in issuing the preliminary outline of the program for the conference announced that the engineering alumni of Columbia University and the alumni of Stevens, under whose joint auspices the conference will be, will welcome to the camp graduates of other colleges and junior members of the national engineering societies. The hours for lectures, conferences, and round-table discussions by some of the leading economists and engineers of the country are to be scheduled so as to permit the men in camp to make full use of the camp's unusually good facilities for land and water sports. The serious part of each day's program will have two main elements: in the morning the lectures and discussions will deal with "The Dollar Factor in Engineering," or "Technique in Calculations Involving Money"; at the open forum and round table discussions in the evening, elements in depression, seasonal and cyclical fluctuations will be considered.

The Carnegie Corporation, on the recommendation of the American Association for Adult Education, has endorsed the project through a grant of $1,500. A joint conference committee of Columbia and Stevens graduates has been formed on which Columbia is represented by Professor James K. Finch of the Columbia University faculty, Mr. Lindsay H. Welling of A. Iselin & Company, and Mr. Edward C. Meagher of the Texas Gulf Surphur Company; and Stevens is represented by Mr. Robert C. Post of Post & McCord, Mr. Walter Kidde of the Walter Kidde Construction Company, and Mr. Thomas W. Kirkman of the Kirkman Engineering Corporation.

The lectures and conferences scheduled for the morning hours will be under the direction of William Duane Ennis, head of the Stevens Department of Economics of Engineering who will be assisted by members of the Stevens and Columbia faculties. The general topic may be suggested by some such phrase as "The Dollar Factor in Engineering."

One special principle with which the work may well start is that of the time factor in money values. Starting from this point the course will deal with such topics as the economic life of a machine or construction. Another topic is the choice between alternatives involving the determination of capitalized cost as a more accurate

method than the one commonly employed of comparing annual operating costs, interest and depreciation.

These topics naturally lead into a discussion of factors affecting the best time for construction of other enterprise: when, for example, is it most opportune to build a hydro-electric plant in contrast with a steam plant? When should financing be by the issuing of bonds and when by the issue of stocks? Some attention may then be given to industrial and governmental financing in general; the pay-as-you-go plan, the sinking fund or term bond, and serial bond; leading to the calculation of sinking funds, the setting up of maturity programs and suggesting the method of determining the yield of a bond to the investor.

In addition to the morning series of lectures and seminars on the money factor in engineering, the Economic Conference is planned to include eight or nine evening lectures and round-table discussions on the business cycle. Four major questions of business depression are proposed for consideration: What is the most significant statistical description of what has happened since the fall of 1929? What statistical approach looks most hopeful for forecasting or for starting a public works program? What is the most significant explanation of what has happened? What to do about it.

The first two questions, bringing out a description of a period of depression, will be discussed by leading financial and government analysts. The third will be submitted to investigators in theoretical economics associated with university faculties and research staffs of private corporations. Under the fourth topic, emergency relief, industrial stabilization, unemployment insurance and long-range planning will be debated by men who have been actively engaged in solving such problems for industrial organizations and civic committees.

The list of participants in the discussion of business cycles and depressions will be published later. By arrangement with the editor of the *Forum*, Henry Goddard Leach, the discussions will be analyzed for publication later.

CLEARING HOUSE FOR MACHINE DESIGN DATA

Sixty teachers of machine design from 52 colleges have joined the newly formed "Clearing House."

Three news letters have been distributed to the participants as well as a contribution on "Super-imposed Diagrams for Studying Link Mechanisms" by Prof. G. B. Karelitz, and one on "Theoretical Considerations in the Design of Spur Gear Teeth" by Prof. F. A. Mickle.

The discussion topic for March was "The Amount of Drafting that Should Be Done in a Course in Machine Design." The many discussions contributed showed a divergence of opinion, but the majority felt that a good course in engineering drawing should precede the design course and that the latter should include enough drafting to show the relative arrangement of the parts of the design project. The making of detailed working drawings consumes too much time which might more profitably be used in other phases of design such as the study and numerical applications of stress analysis, modern theories of lubrication, and problems involved in high speed machinery. The student should be required to express his ideas and results in the form of sketches. Paragraphs from some of the contributions follow:

"Designing is distinctly more than drafting. In engineering organizations with which I have been affiliated the engineer responsible for new designs made the layout drawings, computed the proportions of some of the essential parts and turned the project over to others for the making of detailed working drawings. The engineer's time is too valuable for this.

"The drawing is the form in which the engineer's idea is presented on paper so that the man in the shop can read and interpret it. This drawing can be made by a lower-salaried person having less engineering training and experience—a draftsman as distinguished from the designer."

"If the student has had a real good drawing course previously, the machine drafting should be of the design type without detailing. It should involve essentially the proportioning of parts and questions of manufacture.

"Much of the design I have seen in colleges partakes of the nature of drafting, and hence is of little use in teaching design principles."

"It is my opinion that the engineering drawing should be taught separately from the design courses, but that a student in machine design should be able to make any mechanical drawing necessary for the solution of the problem in hand."

"It would appear to depend upon the drawing content of the curriculum. At this school students come to the course having had only a small amount of drawing. We feel, therefore, that a certain amount of additional practice is essential, but consider the problem work the more important."

"Assuming the student to have the necessary prerequisite courses I should keep drafting work to the minimum. I should consider it necessary in only two situations: first, for graphical methods of solution, as for shaft deflections of varying, forces; second, layouts to determine relative size or arrangement of parts. The design of individual details may be carried on with notebook sketches."

"For an elementary course, especially when the student is not familiar with Mechanics of Materials, part of the time should be devoted to lectures. However, for advanced work the best results are accomplished by spending the entire time over the drafting board. It is just as futile to teach a man how to design without going over the board as it is to teach him how to swim without going near the water."

"The ultimate objective of a design problem is the finished structure or machine. The student cannot, in general build the machine and test it in service. He can, however, successfully make a drawing, which is the nearest he can usually get to the objective. This drawing is a wonderful help in enabling him to visualize the completed machine.

"Skill in the execution of fine drawings, as such, should be secondary in design courses. But this is no reason why we should not encourage neatness, accuracy and precise expression in the 'universal language.'"

"Of course it is vital that problems be given involving fundamental applications of theoretical mechanics and strength of materials, but the working out of these results on the drawing board

is also of great importance. The course in machine design here is in general a drawing course. The student makes a complete shop drawing of each case. Lectures are only a clearing house for the drawing room. I wish we had more time for problems, but I am confident that the students get more out of the course in the way we give it here.

"Industry does not markedly separate design and drafting. The writer was a rolling mill and steel works draftsman for nine years and has also taught this subject for twenty-four years. In no case have I seen the designing engineer simply making freehand sketches to be worked out in the drawing room. He always made complete general drawings of his machine, making his calculations and building his machine on the drawing board. The designer must have more than just the ability to figure stresses in machine parts, and it would be only a waste of time to turn over free hand sketches to the drafting room."

"There is always the temptation to lay out college courses that will be of immediate 'practical' value after graduation. Engineering courses should be designed to make it possible for the student to obtain a maximum amount of fundamental knowledge that will have general application. His intensive training should be in the analysis and solution of problems. It is the duty of the industrial concern that employs the young college graduate to train him and teach him the standard practices of the industry and their own particular organization. The engineering graduate will have far greater opportunity if he is equipped to tackle design problems by the application of fundamentals. Extensive training in drafting is only more apt to chain him to the drafting board after he takes his place in industry."

"Too much detail drawing becomes tiresome and time consuming with subsequent fostering of boredom and indifference in the student. This is accompanied by loss of valuable instruction in more extended subjects. Nevertheless, it seems insufficient merely to teach rational methods without some application to specific problems. Some drawing is necessary to develop sense of proportion and to familiarize with the design problem. Some setting down of ideas in detail is necessary to direct attention to the importance of cost, methods of making and assembly, use of standard parts, finish, etc. I do not advocate, however, excessive

drawing time, only that necessary to illustrate how things are done, and the precautions necessary to observe in designing for production."

"My feeling is that drawing done by the student is time-consuming and is of less importance than the more fundamental principles underlying machine design. Drawing as done in a commercial office is largely a matter of adopting standards and requires a thorough knowledge of manufacturing processes, knowledge which the student cannot afford the time to acquire while in college. I feel that a well planned course in machine drawing should precede the course in design.

"There is an ever increasing difference between a designer and a draftsman. Students are unable to make this distinction. Too much time spent on the drawing board in classes in machine design leads the student to the erroneous idea that designing is drafting. He thereby fails to grasp the more significant aspects of design. Even though he may be talented in this work he is apt to avoid it if he gets the erroneous impression that a machine designer must spend much of his professional life over a drawing board."

"In machine design much time should be spent in the solution of problems involving an application of the fundamental principles of mechanics to the strength and proportions of machine parts. Each of these problems should be accompanied by a pencil sketch illustrating the problem and showing all dimensions and other data pertinent to the problem. After this, one or more complete machines should be designed under conditions that simulate as nearly as possible those of an engineering office. Here the note-book should receive first attention. Aside from this the teaching of mere technique in drafting does not have an important part in machine design."

The ideas of teachers outside the clearing house are also welcome.

FRANK L. EIDMANN, *Chairman.*

COLUMBIA UNIVERSITY.

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

Program: Purdue Meeting Engineering Drawing Division

I. *What may be done to broaden the field of service of the Engineering Drawing Department*

A. Teach graphical expression in its proper relationship to the specialized fields of engineering as well as by promoting drafting as an appropriate entrance to the engineering profession.

B. Increase the interest of the teacher of graphical subjects not only in the subject matter, but also in the relations subject matter has to other engineering subjects, and in a scientific study of methods of teaching.

C. Survey the engineering education field looking towards the establishment of subjects to be appropriately included as within the scope of an Engineering Drawing Department and the ideal organization for the teaching of Engineering Drawing and allied subjects.

II. *Art in Engineering Design*

A. Historical reasons for development of the artistic in design as found in the experiences of previous civilizations.

B. What may be done in elementary drawing courses to develop the artistic sense.

C. Discussions of:

1. Are the habits of neatness, accuracy, and techniques of drafting necessary elements in the development of the artistic sense; artistic drawings?
2. What use of models and modeling should be made in this development of the artistic sense and the artistic drawing?
3. What effect is the increasing conventionalization of drawings going to have on the problem?
4. What immediate changes may be made in drawing courses to aid in the development of the artistic in drawing?
5. Should we have an intermediate course between the present elementary courses and those in design to take care of the problem?

III. *Summer Session Committee Reports*

Committee No. 1: Aims and Purposes of Engineering Drawing Courses:

The committee believes that the aims and purposes of Engineering Drawing will be accomplished when students: (1) understand the principles of orthographic projection; (2) are able to use drafting instruments with reasonable skill; (3) are able to do good lettering; (4) are familiar with dimensioning practice and standard conventions; (5) are able to do acceptable freehand sketching; (6) understand the principles of pictorial representation; (7) are impressed with the necessity for correctness, accuracy, neatness and logical arrangement of any information which is to be presented in graphical form.

Committee No. 2: Methods of Teaching Engineering Drawing:

The teaching program recommended includes (1) Home Study and Preparation; (2) Recitation including lectures; (3) Drawing Room Periods.

Committee No. 3: Aims and Purposes of Descriptive Geometry:

The committee expressed the opinion that the aims and purposes of Descriptive Geometry may be grouped under two heads: (1) Mental training, including (*a*) the development of the power of visualization, (*b*) training in the power of analysis, (*c*) experience in following instructions; and (2) Graphical training, including (*a*) training in accuracy and neatness, (*b*) the adherence to standards, (*c*) experience in technique of graphics.

Committee No. 4: Methods of Teaching Descriptive Geometry:

The committee recommends "that a program consisting of class periods, drafting periods, home work, tests or quizzes and examinations be accepted as an approach to the ideal method of teaching descriptive geometry."

Committee No. 5: Coördination of Drawing and Descriptive Geometry with Other Courses:

". . . In order to coördinate with other courses in either a preparatory or a supplementary manner, it is essential that the departments keep in touch with each other—much of profit is available, if the example afforded by the industries is followed. Likewise, it is highly important to know whether a student who has acquired a certain proficiency is still progressing—or whether on account of the lack of emphasis, he is a 'graphical' degenerate."

SOME UNSUNG ASPECTS OF COÖPERATIVE TRAINING

BY F. E. AYER

"What percentage of your coöperative students who should be working are now employed?"

"About twenty-five per cent."

"Ah! Then the coöperative method fails in times of depression?"

"In true Yankee fashion let me answer your question with another. What percentage of your 1930 graduates are now employed?"

"I haven't the exact figures, but probably not over half and, perhaps, not more than twenty-five per cent."

"Ah! Then the full-time method fails in times of depression?"

Obviously, "No" is the answer to both questions. All engineering colleges are trying to fit young men to go out and take their places in the profession as practiced under our existing economic conditions. In this organization of society personal services have a market value very largely dependent upon supply and demand, and the younger the embryo engineer realizes this fact, the sooner is he fitted to plan his personal budget accordingly. Therefore, there is a distinct advantage, although a painful one, in graduating at a time when employment is difficult to get. And by the same reasoning, the coöperative student who goes through such an experience previous to graduation starts his professional career with a very definite knowledge, gained through experience, of the uncertainty of continuous employment.

But what are these students doing who are unemployed? Most of them are continuing in school full time with the idea of spending a proportionately longer period at work when conditions are such that this is possible. Many are doing so at great financial inconvenience, but they are learning a lesson in economics which might have helped to prevent the present condition had there been a wider knowledge of it.

Another interesting by-product of coöperative training is the effect upon the student of his contact during his formative years with mature men. A freshman comes in to complain to the coördinator about his work and its lack of educational opportunities. His whole conversation is a striking example of kiddishness. Sometime between two and three years later, he comes in again, and the coördinator realizes at once that this immature student has evoluted

into a man. When we remember that the full-time student has very little contact with men, beyond his associations with his instructors, and that he lives almost entirely in a somewhat secluded world of immaturity, it is not surprising that he gets an erroneous idea of life as it is actually lived, and that he places exaggerated values upon winning football games, making a particular fraternity, or shining at the Junior "Prom."

The coöperative method teaches by experience life in a highly competitive society and hastens manly development through contact with adults.

COLLEGE NOTES

With the opening of the next school year, **Case School of Applied Science** will offer an extensive postgraduate curriculum open to both men and women.

The graduate courses will lead to the Master of Science Degree, subject to the requirements of admission, courses to the extent of thirty semester hours, and the completion of a thesis directed by the head of the respective department.

Departments ready to offer such postgraduate programs next year are those of Astronomy, Mathematics, Physics, Mechanics and Hydraulics, Civil Engineering, Mechanical Engineering, Electrical Engineering, Metallurgical Engineering and Chemical Engineering.

President Wickenden states that this development of the Case graduate curriculum is a direct advance in preparation for the part Case will take in the graduate work of the new University Foundation of Cleveland being arranged by Case School of Applied Science and Western Reserve University. The president aims to build up a curriculum which will offer graduate work in engineering the equal of any, both in courses and in equipment.

A College of Fine and Applied Arts for the **University of Illinois** was approved by the University board of trustees at its meeting March 12. This brings the total colleges on the Champaign-Urbana campus to seven, in addition to four schools. Three units—the College of Medicine, the College of Dentistry and the School of Pharmacy—are located in Chicago.

This new college has been made possible by the coördination of certain fields of work now being offered by the institution, which have a common point of view, for purposes of administration and development.

The movement has been under consideration since 1921. At the beginning, it was announced, the new college will include the School of Music, department of architecture, department of art and design, division of landscape architecture, including the option in city planning.

Although first proposed in 1921, for one reason or another it has not been practicable to make this reorganization heretofore, although the proposal has remained under consideration pursuant to the action of the University Senate in October of that year, which voted that the matter be given further study with the view to

presenting to the Senate a plan for such a college when it is possible to provide adequately for such an additional unit.

In 1928, a special committee of the faculty was appointed to make specific recommendations for the organization of a College of Fine Arts. This committee made a detailed report after five or six months of study, which report has furnished the basis for the specific recommendations of the committee on educational policy, subsequently approved by the board to-day.

For the time being, admission requirements to the several units remain as at present, students now registered in the present curricula will be allowed to continue these curricula to graduation, and the degrees offered will be, until further provision is made, those given upon the completion of the present curricula.

The recommendations of the committee also suggested that the cultivation of æsthetic taste on the part of the student body at large should be considered one of the major aims of such a college, and that suitable subjects for the development of general artistic appreciation should be so presented as to make them desirable as electives in other colleges. The committee also stated in its report that it is its understanding that the plan proposed does not commit the University to any large additional expense nor to any elaborate expansion of activity.

Massachusetts Institute of Technology.—The Guggenheim Foundation awarded the Guggenheim Memorial Fellowships to two Professors at the Institute. One award was made to Dr. Otto G. C. Dahl, Associate Professor of Electric Power Transmission. Under the provisions of the Fellowship Dr. Dahl will make a study of European practices in electric power transmission.

Dr. George Scatchard, Associate Professor of Physical Chemistry, received the other award, and will make studies in the theory of liquid solutions, in consultation with certain European scholars.

BOOK REVIEWS

Counting and Measuring. By H. Von Helmholtz. Translated by Charlotte Lowe Bryan with an Introduction and Notes by Harold T. Davis. D. Van Nostrand Co., Inc. Price $2.50.

This volume of 70 pages is divided almost equally between the Introduction and the Translation. The former, in a satisfactory way, surveys "briefly the background of present-day mathematical and physical foundations," and measures "The advance which philosophers in these sciences believe they have achieved." Quoting further from the first section: "The subject of number and its relation to the description of nature possesses both ontological and epistemological aspects. It is in part psychological and in part philosophical. Basic tenets may often be reduced to question of preference . . . the psychological elements which underlie the definition of number given by philosophers . . . may be grouped into three types: Those which seek to associate number with an *a priori* intention of time; those which seek to coördinate the idea of number with space; those which affirm that number is a concept *sui generis* and is related only secondarily if at all to time and space. But closely associated . . . is the more baffling concept of boundlessness or infinity. . . . paradoxes of Zeno . . . space composed of points . . . limits. . . . We thus see that the problem of number is bound up with the psychological question as to its origin in man's thoughts, with the ontological question as to the nature of a point, and the epistemological question as to the nature of our knowledge of infinity. We shall trace in brief outline the historical progress of these questions."

The topics of the remaining ten sections are: Time as the Origin of Number; Space as the Origin of Number; The Origin of Modern Number Concepts; The Continuum of George Cantor; The Logistic School; The Intuitionalism of Brouwer; The Formolism of Hilbert; Physical Empircism; The Postulate of Boundedness; The Physical Continuum.

The translated article, Counting and Measuring, and the Notes present an interesting and somewhat extended discussion of number and the socalled axioms of number—definitions, nature, origin, generalizations, logical implications, and physical significance.

K. D. S.

Electrical Laboratory Studies. By W. L. UPSON of Washington University. Published by McGraw-Hill Book Company. 178 pages. Price $5.00.

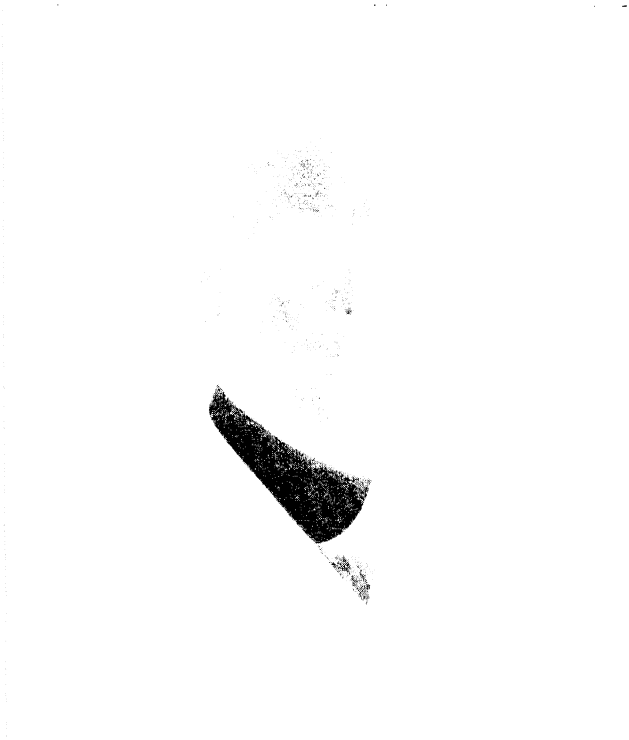
This book deals with direct current principles as applied in the laboratory. Approximately two-thirds of the book is given over to such items as resistance, meters, heating, etc., and the balance to direct current machinery and a short chapter on alternating current circuits.

The book opens with an introductory chapter pertaining to instructions on writing reports, care of instruments, protection of instruments and other pertinent topics. Chapters following this, take up Ohm's law, meters, measurement of resistance, batteries, lamps, heating, magnetism, generators, motors and alternating current circuits.

The author spends considerable time in discussing electrical heating and the measurement of resistance. Special experiments, such as the construction of an electric furnace are given. Very little time is given to experiments involving magnetic principles.

There are about thirty experiments which are devoted to direct current machines. These involve the characteristics of motors and generators, their efficiencies and operations under different conditions. Most of the experiments have preliminary information concerning the factors that are involved and which may be read over before data are actually taken. Each experiment is numbered and directions are given for performing it.

R. W. A.



H. S. Boardman.

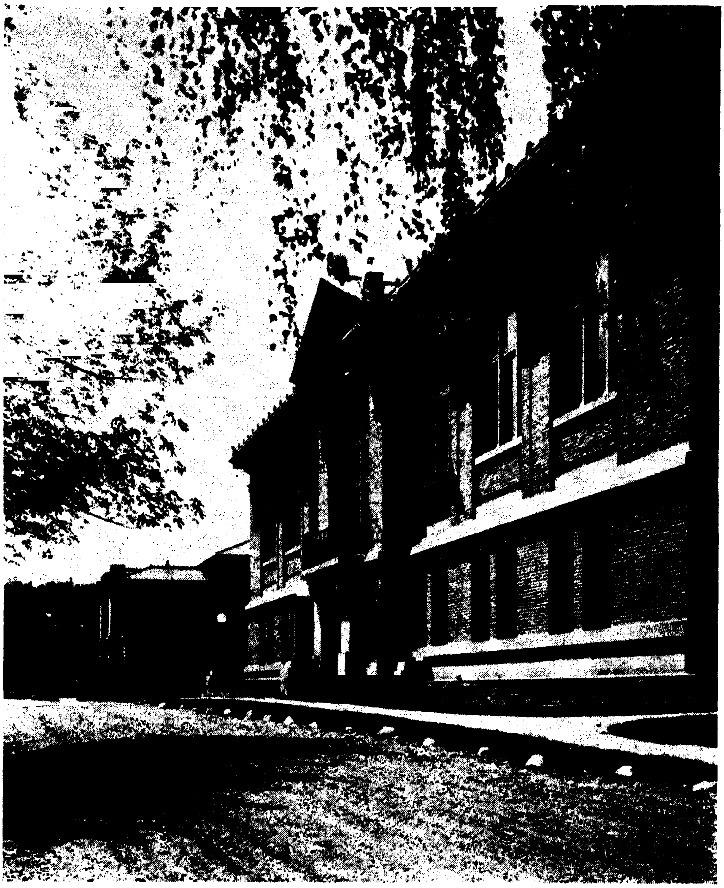
HAROLD SHERBURNE BOARDMAN, PRESIDENT, SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

Harold Sherburne Boardman was born in Bangor, Maine, March 31, 1874. He received the degree of B.C.E. at the Maine State College in 1895; was a graduate..student at the Massachusetts Institute of Technology in 1896, receiving his C.E. in 1898. The University of Maine conferred the degree of Dr. Eng., in 1922; LL.D. Colby in 1927; Dr. Eng. Rhode Island State College in 1928; and LL.D. at Bates College in 1929.

President Boardman was tutor in drawing at the University of Maine 1896–99; draftsman and designer at the Union Bridge Company 1899–1900, American Bridge Company, 1900–01; instructor in civil engineering, 1901–03, associate professor 1903–04, professor and head of the civil engineering department 1904–26; dean of the College of Technology, 1910–26 and president since 1925 of the University of Maine.

President Boardman has always been actively engaged in many important hydrographic, structural, hydraulic and highway projects and active in professional and educational societies.

President Boardman was a member of the Council, of this Society in 1919–24, Vice-President in 1923–24, and President in 1930–31.



Purdue University Library

ENGINEERING SCHOOLS AND DEPARTMENTS OF PURDUE UNIVERSITY

By W. A. KNAPP

Professor of Engineering Extension and Secretary, Engineering Experiment Station

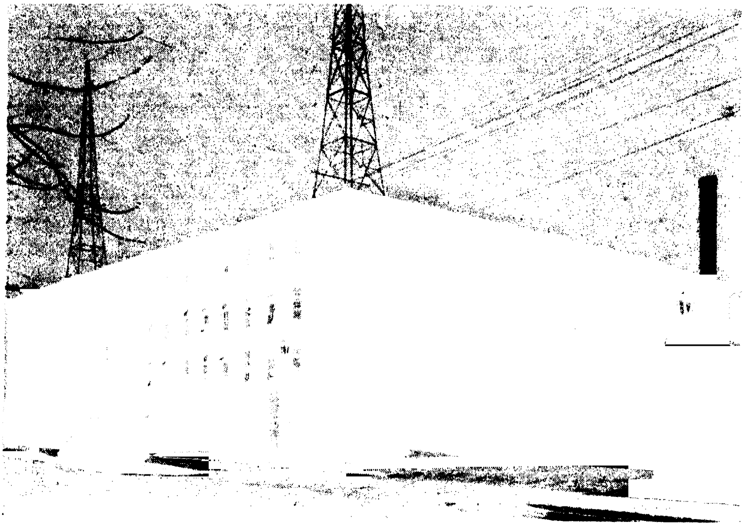
Purdue University, the land grant university of Indiana, was founded in 1869. In accordance with an act signed by the Indiana General Assembly, it bears the name of John Purdue, a citizen of Lafayette, who donated a substantial sum of money and land to aid in its establishment. The first classes were conducted from March to June, 1874, several years being required to organize the courses, to construct the three original buildings, and to get the University actually under way. The first full academic year began in September, 1874, with six faculty members and 65 students. The first degree was granted in June, 1875.

Purdue University offers four-year curricula in Engineering (Chemical, Civil, Electrical, Mechanical, and Industrial Education), Agriculture, Home Economics, Physical Education, Pharmacy, and Science. Although all schools have shown a rapid and healthy growth, that of the Schools of Engineering has been the greatest.

The four-year curriculum in the School of Mechanical Engineering was first offered in September, 1882; and one student was graduated from this course in June, 1885. The School of Civil Engineering was started in 1887; the School of Electrical Engineering in 1888; and the School of Chemical Engineering in 1910. The graduating class of 1888 listed five civil engineers and five mechanical engineers out of a total of 30. In June, 1930, 46 men were graduated in chemical engineering, 79 in civil, 111 in electrical, 102 in mechanical, and 3 in industrial education—making a total of 341 engineers out of a class of 547. Degrees conferred at the end of the summer session brought the number of engineering graduates for 1929–30 to 382.

On February 15, 1931, 4,744 undergraduate students were enrolled in Purdue University. The enrollment in engineering was as follows:

(*a*) Undergraduates—		
Chemical Engineering	393	
Civil Engineering	553	
Electrical Engineering	781	
Mechanical Engineering	1,117	
Industrial Education	25	
Total		2,869
(*g*) Graduate Engineering Students		90
Total		2,959

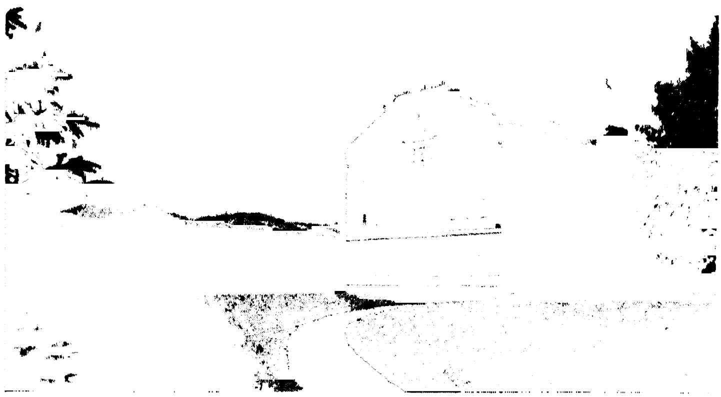


Electrical Engineering Building

Civil Engineering Building

This represents a total increase of 143 undergraduate students over the enrollment on February 15, 1930.

Three Deans have been at the head of the Schools and Departments of Engineering since the Engineering Division of the University was organized into schools in 1890. Wm. F. M. Goss, the first Dean of Engineering, served from 1890 to 1907, having been on the staff of Purdue University since 1879. Charles H. Benjamin came to the University from Case School of Applied Science in 1907 and served until 1920. Andrey A. Potter, the present Dean of Engineering, came to Purdue in 1920 from Kansas State College where he had served as Dean of Engineering for seven years.



MICHAEL GOLDEN SHOPS

The Schools and Departments of Engineering are organized to carry on three distinct services of value to state and nation. These services are undergraduate and graduate instruction, research, and extension.

Engineering instruction is carried on through four schools, Chemical, Civil, Electrical, and Mechanical Engineering, and two Departments, Applied and Practical Mechanics, with a total teaching staff of 108 people. The engineering curriculum in Industrial Education is also administered under the Dean of Engineering. Since 1885 there have been graduated 6,870 engineers in the regular four-year courses in engineering. Table I shows the enrollment and number of graduates by years in each engineering course since 1908.

TABLE I

TABLE SHOWING THE ENROLLMENT AND NUMBER OF GRADUATES IN THE ENGINEERING SCHOOLS AND DEPARTMENTS SINCE 1908 (GRADUATE STUDENTS NOT INCLUDED)

Year	Undergraduate Enrollment by Schools						Engineering Graduates					
	Chem.	Civil	Elect.	Mech.	Ind. Edu.	Total	Ch.E.	C.E.	E.E.	M.E.	Ind. Edu.	Total
08–09	51	441	432	373		1,297	1	75	78	86		240
09–10	67	385	408	346		1,206	1	79	72	70		222
10–11	79	346	401	310		1,136	9	79	71	62		221
11–12	74	309	375	342		1,100	10	79	60	50		199
12–13	105	249	351	339		1,044	14	60	69	42		185
13–14	130	232	345	365		1,072	13	36	68	54		171
14–15	138	240	321	348		1,047	13	46	59	58		176
15–16	171	200	312	351		1,034	18	39	52	56		165
16–17	198	210	317	346		1,071	24	42	49	58		173
17–18	189	167	239	254		849	16	23	33	36		108
18–19	270	337	417	638		1,562	19	15	27	50		111
19–20	296	350	463	589		1,698	31	36	37	69		173
20–21	266	397	499	635		1,797	39	56	55	71		221
21–22	232	403	545	638		1,818	45	62	68	106		281
22–23	183	417	520	603		1,723	54	82	90	130		356
23–24	167	412	556	543		1,678	30	63	76	91		260
24–25	172	476	637	535	2	1,822	40	69	85	119	1	314
25–26	171	490	689	569	4	1,923	20	69	89	107	5	290
26–27	207	538	773	548	3	2,069	33	73	76	72	1	255
27–28	229	565	765	676	11	2,246	17	79	82	98	2	278
28–29	254	587	778	817	14	2,450	30	78	121	109	5	343
29–30	300	621	787	980	21	2,709	49	92	125	113	4	383
30–31	393	553	781	1,117	25	2,869						
Total Graduates							526	1,801	2,152	2,373	18	6,870

Engineering research is carried on by the engineering schools and departments through the Engineering Experiment Station, which was organized in 1917. This division has grown from one paid research assistant in 1917 to sixty-five full-time and ten part-time research men in addition to the teaching staff, and graduate and undergraduate students who have been carrying on research during the current year.

Research projects are being carried on in the fields of chemical, civil, electrical, and mechanical engineering, with major attention to railway, concrete, high voltage, and welding problems. Results of completed tests have been published in thirty-four Experiment Station Bulletins. The Engineering Experiment Station spent $285,000 for research during the past year, of which $240,000 was furnished by coöperating agencies.

ANDREY A. POTTER, S.B., D.ENG.,
DEAN OF ENGINEERING, PURDUE UNIVERSITY

Engineering extension carries the benefits of the Engineering Schools and Departments and of the Engineering Experiment Station to citizens of the state not in attendance at the University. The services of this department include conferences and short courses on the campus, coöperation with state organizations in their meetings, extension classes in industrial centers, services of extension specialists with special attention to foremanship training, steel treating, and highways, radio talks, talks to technical and non-technical groups, vocational guidance talks to high schools, and publications. During the past year more than 15,000 people were reached directly through the various activities of the Engineering Extension Department.

LIBERALIZING OBJECTIVES IN ENGINEERING EDUCATION

By DEAN L. E. AKELEY,
University of South Dakota, Vermillion, S. Dak.

The special urgency of the matter of this paper was suggested by the nature of the reception given last summer at Montreal to Elliott Dunlap Smith's paper on "Management." The writer judges the reception of that paper by the limited interest shown by the attendance at the session devoted to it, by the character of the discussion which followed, and by comments afterwards heard. It seemed as though the matter treated in that paper does not *fit in* especially well with that which has constituted the subject matter of engineering education. The methods for developing a sensitiveness to human relations seemed hardly congenial to men trained in the ways in which the great body of engineers have been educated. It certainly can be no exaggeration to say that Elliott Dunlap Smith's paper on management at the Montreal meeting was not very well assimilated by the membership of the Society. Engineers seem to be lacking in that background that would welcome into the foreground of their interest and professional consciousness such psychological and human considerations as those to which Smith's paper invited the attention of the S. P. E. E.

But the engineering profession is being challenged by new opportunities and new obligations. Engineers are, no doubt, being called upon to project educational ways that transcend the limitations of those in which they themselves were prepared for entrance into the profession. This constitutes a summons to a particularly difficult task. But no difficulties can justify neglect of the terms of a new call to meet a new time.

There has been more or less demand on the part of certain engineering deans and professors for the introduction of a larger number of so-called cultural subjects into engineering curricula. These demands have not met with any very marked success. It is the belief of the writer that they have enjoyed all the success they deserve. It is not a promising educational proposition to impair the excellence of the engineers present training by introducing the materials of a culture that has become exotic to the civilization which is now in process of evolution. We may have in time an academic culture that will be more fully indigenous to the broader popular culture of the modern world. If the present subject

matter of the engineering curricula be presented and developed in the student's conception and mastery of it, in a way to sensitize his mind to the kind of problems that the contemporary world is facing, there will be plenty of cultural appeal in it all. The very course that calls upon the student for cultural interest will all the more effectively focus his energies upon his narrower vocational objectives.

There are many other considerations besides those suggested by the reception of Smith's paper which should give us a bad conscience about a certain ineffectiveness in current engineering educational objectives. In the December *Harper's* was an article by Harold J. Laski on the "Limitations of the Expert." That paper presents matters that deserve consideration, together with interpretations and conclusions that may be open to some criticism. In concluding his paper Laski says, "We must ceaselessly remember that no body of experts is wise enough, or good enough, to be charged with the destiny of mankind. Just because they are experts, the whole of life is for them in constant danger of being sacrificed to a part, and they are saved from disaster only by the need of deference to the plain man's common sense. . . . The experience of the expert is so different, his approach to life so dissimilar, that expert and plain man are often impatient of each other's values. Until we can somehow harmonize these, our feet will be near to the abyss."

Perhaps, there is no body of experts less deserving of Laski's criticisms than are the professional engineers. But even they deserve these criticisms in notable measure. Laski holds that experts in government and in economics require the politician to draw the line beyond which their very prestige as experts disqualify them for consideration. And in general he claims that the expert must have deference for the plain man's common sense. Why would it not be good for society if the expert could, along with all that acquired knowledge and all those abilities which make him expert, preserve his native common sense, cultivated and developed under a sensitiveness, awakened by his education, to the human and cultural facts which condition the situations which call for his expertness. Is any plain man or are all the plain men together, who happen to rise to political, financial, or industrial eminence, good enough or wise enough to be intrusted with the destiny of mankind? If we are going to escape the abyss by harmonizing the values of the plain man and those of the expert had we not better concern ourselves with those features of the expert's education during his plastic age which so narrow his outlook as to make him dependent upon plain men whose rise to eminence comes about from a great variety of causes. The engineering expert's training has a scientific basis. It is certainly important to mobilize all the scientific resources of the world, including those which are found in the pro-

fessional engineers, for the solution of the challenging and threatening problems that confront modern industry and economic organization.

The contemporary troubles of civilization, constitute, on an exceptionally large scale, the same kind of problem that has been solved in the past by individual genius in scientific discovery. To carry such magnified projects of research, through the coöperation of competent leaders with many diversified interests and of understanding and intelligent followers, is a new challenge. It would look like sheer folly for plain men to dominate the situation, indispensable as their coöperation undoubtedly is. To carry out such projects even by a process of more or less successful muddling through, requires a breadth of understanding on the part of applied scientists, pure scientists, and practical men such as the education of the past has never begun to conceive. It demands an understanding of scientific method on the part of large numbers of persons and a conscious application of it. More than all else, it calls for an appreciation on the part of the rank and file of scientific men, for rare and exceptional kinds of ability which are indispensable in certain stages in the processes of discovery and application. The call is for each one to find his place and keep his place in the great project. To this end much dependence must be placed on the intelligence and knowledge of the individual himself. The great thing that a liberalized education should do is to render the average educated person appreciative of the rôle of—whatever you may call it,—intuition, genius, uncommon common sense, and to render him appreciative of the limitations of the great majority of persons who lack these qualities, even though they have shown themselves susceptible of the most elaborate education. This is a commentary on the present degeneration into scholasticism of most academic research. When students should be getting a grasp of scientific method in all its ways, they are forced into intensive effort in the most limited aspects of it. This intensive effort in limited directions shuts out the possibility of the student's making a fair assessment of his own individual type of ability and of gaining an appreciation of abilities that are out of his range. I know all the objections that will be immediately raised against this statement. But the present pessimism among research men in physics can be traced to this sort of blindness. Many men when properly trained have the ability to apply rigorous deductive methods to the insights of intuitive scientists like Dirac and yet all their progress in clearing up desperate situations that have developed in contemporary physics must wait patiently upon the intuition of the Diracs and the Einsteins. Lesser men may verify these intuitions. The verifications and deductions are laborious and indispensable. But this is a work of

utter futility without the epoch making work of genius. Genius can never be fathomed, but the conditions under which it works and succeeds can be studied and that kind of study will yield an appreciation of the limitations of men of the merely deductive and analytic type, that is most comforting and reassuring, and salutary.

Right here in this connection it must be observed that the rôle of inductive scientific method is not recognized in current educational procedures as it must be if the objectives here pointed out are to receive adequate consideration. Induction is a jump. It is never a jump in *total* darkness. The jump must follow a preparation, consisting of the most strenuous efforts to clear up a perplexed situation. This preparation is followed by what Graham Wallas calls "Incubation," ending in what he calls "Intimation" and "Illumination." The inductive jump completed, has to be followed by the rigorous deductive procedures and verification. But great generalizations and fertile applications of general principles to concrete problems are reached by something that can be called nothing less than a jump, which only a certain type of mind can make with any assurance of success. Yet the mind that cannot do this needs to appreciate his own limitations in this regard and needs to recognize his dependence upon a genius that he can never claim for himself. The present exclusive emphasis on deductive processes as distinguished from the inductive is a serious defect in current scientific education. The defect is not even remedied, except in a very partial way, even in post-graduate work, which, however, lies outside the range of most engineering education.

What is needed above all else in all education today is a cultivation of a sense for those qualities of mind which have given the modern world its science and its applications to the uses of life. Such an education will be liberalizing and will give a culture that is not an exotic. To the end of shaping such liberalizing objectives, the first requisite is an adequate philosophy for our education. Such a philosophy must embrace scientific method completely in all its stages and phases. A philosophy adequate to educational procedures in the interests of an indigenous culture, would be, beyond all question, a pragmatic and realistic philosophy. The whole matter lies quite aside from the questions that are currently discussed by technical philosophers.

Pragmatic philosophy means, in the sense of what the educational situation demands, one that will emphasize in scientific method the common sense or intuitive approach to problematic situations.

It will be claimed that a pragmatic philosophy taken in this sense will demand educational procedures for the freshman and sophomore years, that will take care of interests that are one and

the same for a future researcher in pure and applied science and for the engineering practitioner and for the leader and the follower alike in those economic and political crises for which every good citizen should be trained and prepared.

It would be disastrous to confuse the educational objectives for the future research man and for the engineer. Engineering and research are quite distinct when it comes to the more distinctively engineering courses of the junior and senior years. But it is equally a disastrous idea not to recognize that the fundamentally pragmatic approach to problematic situations is the same for engineers and for researchers. Both are special cases of the use of one and the same scientific method, which it must be the chief task for all who are engaged in any kind of education to understand, so far as that method has emerged from the intuitive processes of the great discoverers of science into the light of clear and intelligible statement. The ways of scientific induction as distinguished from deduction will never be capable of clear statement in a minutely detailed way. But the *conditions* under which great inductive insights are achieved can be clearly and distinctly outlined and introduced as subject matter in every scientific course. It is just this feature that will put a new element into the subject matter of scientific courses. Such matter will impress all students with the fact that there is an inductive process in science and that it is to be treated with respect. Respect for it means that those who have very limited abilities for the achievement of inductive insights must confine their intellectual activities to the critical deductive treatment and experimental verification of the work of men of genius and must patiently wait upon the work of such men for the cues to their own activities. The days of the prophets will return, and of reverence for the prophets to an age when reverence is more or less submerged.

The main question then is the character of the pragmatic approach to a problematic situation. No words are more misleading in many of their implications than the words "applied science." They seem to imply to many persons that science is something already finished, ready for application, *i.e.*, ready to be externally applied to a troubled situation like dope to a sore thumb. The truth of the whole matter seems rather to be that our science, our whole conceptual paraphernalia is not all ready prepared for application to the problematic situation that confronts either engineer or pure scientist. The researcher often finds that his scientific body of principles, laws, concepts, universals, and complexes of universals, must be redefined and reorganized before they can be used to interpret a new experimental situation. The engineer seldom experiences any such revolutionary upset as this in the use of

fundamental principles of science. But he does always experience something every bit as drastic in character in organizing the particular pattern of laws, principles, and concepts for his particular problem and he experiences what is equivalent to a veritable revolution in reorganizing his stereotyped understanding of principles. That is, the engineer experiences all this in greater or less degree as he attacks problems of greater or less difficulty. The generalizations of science never possess for us that generality that we imaginatively impute to them. They are always stereotyped to the particular situations in which we have formerly used them. If they were not so stereotyped we never could apply them to any concrete case at all. They would not possess those concrete earmarks that relate them in our minds to the sensible features of our concrete situation. We never see entropy and heat energy roosting around a diesel engine. We may imagine that we sense temperature in it. But even that is a stereotype and not a concept. Principles and laws are abstractions; so are all our physical concepts. There is a superstition among physicists that these are not abstractions. This superstition arises from the failure to realize that we always limit the generality of them by stereotyping them to the particular situations in which we have used them. Being stereotyped to former situations they are not applicable to the present situation until they have been pretty drastically smashed up in their stereotyped character. On this account anyone who is trying to apply principles to a new situation is between the "devil and the deep blue sea." His principles would not be applicable to any situation if they were not thoroughly stereotyped and since they are stereotyped they are inapplicable to the new situation. This is a dilemma that no logic can solve. Life only can solve it. And life in this case means achievement of an insight by genius. And since many men do succeed in applying principles to new situations, genius must be much more common than is generally assumed. Genius is probably an exceptionally high development of a variant of common sense. In applying principles to new problems, the laws, the principles, the universals, the complex patterns of universals must be rediscovered *in* the new problem, not applied *to* it from without. To do this successfully demands genius of the same nature though not of the same intensity as was exhibited in the original discovery of scientific generalizations. This is the chief lesson that the engineering graduate has to learn during the first few years out of college in the process of vindicating the proposition that he is not an educated fool. We are all educated fools to the extent that we do not recognize that every particular situation has to be approached from the standpoint of common sense. We must let the new perplexity talk to us in its own language and we must forcibly repress our

knowledge, which has cost us so much and which we love to use. We must force that knowledge and the pride that goes with it into the remotest background of our consciousness or even sub-consciousness. Nothing less drastic will ensure that just that part of our knowledge that is relevant will trickle through. The spirit of Elliott Dunlap Smith's address and the spirit of his book, "Psychology for Executives," is just the spirit of the common sensed and pragmatic approach to problems. The book reads in a way to give one the impression that he had learned his psychology in the everyday troubles of an industrial executive. However, a little reflection will persuade anyone that Smith must have in some way acquired a good knowledge of psychology in advance of managerial troubles. But it is equally obvious that he *relearned* all his psychology in dealing with industrial troubles. And he clearly indicated at Montreal the agony through which intuition will carry anybody in relearning what he thinks he knows. The process as he outlined it was something like this. He met the troubles each day as they rose and met them as his practical sense applied to an analysis of the whole situation suggested. He often failed. He faced the same dilemma described above that is always involved in the application of principles to a new problem. Life has to solve a dilemma that logic cannot touch. It is a re-enactment of the drama of Jacob wrestling all night with the angel. Defeat and humiliation is the apparent termination of the whole event. But only apparent, for the Jacobs. For Jacob held the angel, refusing to let go until he had received a blessing. In the case of the industrial manager the blessing is an insight into human situations and the rediscovery, in the kind of problem that has been inflicting defeat, the principles of psychology and the scientifically formulated laws of human nature.

Smith asked the question at Montreal, "Can the Universities Teach Management?" His answer was, No. But they can make students sensitive to human relations and speculative about them. The same question can be asked about everything that universities try to teach. And the answer must be the same as Smith gave, an emphatic No. We cannot teach anything of any great importance aside from a few indispensable techniques. The greatest thing we can do is to make students sensitive to and speculative about the great realities of scientific method, so that when they enter practical life there may be some hope that some of them will rediscover the principles of science in their work. Probably the one feature of Smith's ideas that repelled interest is the one outstanding criticism today for engineering and all other kinds of education.

This then may be the gist of the pragmatic philosophy of education. William James said there were two factors in both life and philosophy, the Thick and the Thin. They master life who

dwell in the thick of life and find *in* life that which transcendentalists place outside of life, that thin conceptual structure that we call science. It is thin and abstract; but, found in perplexed situations, it appears as order coming out of chaos, giving life its beauty and its meanings, its forms and comeliness. The science taught in the textbooks is an abstract from these meanings of life, put into cold storage during the passage from the concrete problems of the past to those of the future.

To pose the problem presented in this paper is more important than a detailed discussion of one of its rather successful solutions in the teaching of one science, viz., physics. There will be other solutions better than the one already fairly well achieved, if the problem in its vast significance is once grasped. The solution of it will conflict with current standardizations. However the solution already well toward completion meets all current standards. The advantage is that it does more. The *more* is the significent thing. It is the *more* that, in addition to its own intrinsic value, makes more effective and more compellingly interesting the achievement of the less, *i.e.*, the meeting of current standards. Standardization would choke off this more. We merely need to heed the words of the Principal of McGill in his address last summer when he said as nearly as I can remember it, "We need to forget standardization and concentrate on standards."

THE CALCULUS IN ENGINEERING SCHOOLS

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I

The calculus is a required study in all engineering schools of collegiate grade. Generous provisions are made for it in the curriculum. In an increasing number of institutions these provisions are extended to cover advanced courses in the subject. All this is as it should be. The calculus is the engineer's distinctive arithmetic, very much as trigonometry is that of the surveyor or commercial arithmetic of the banker. The engineer has much to do with related variables, whose variations follow a definable law and it is with problems of this sort that the calculus is concerned. Thus to the engineer the calculus has an utilitarian as well as a cultural interest, and in a sense the former is dominant. Even in cases where the calculus is not immediately useful, a good understanding of the physical principles underlying engineering problems is scarcely possible without some acquaintance with it. The engineer also must know something about differentials if he is to have access to the more advanced professional literature. It is not too much to say that familiarity with the elements of the calculus should form a part of the intellectual equipment of the educated engineer in the same way that some idea of the Copernican astronomy and the theory of evolution should form a part of the intellectual heritage of every educated man.

II

But notwithstanding the acknowledged importance and intrinsic interest of the subject, both from a cultural and practical point of view, the calculus has always suffered from certain blighting traditions which have dampened the ardor and retarded the progress of the student. At a meeting of the S. P. E. E. twenty years ago, the teaching of the calculus to engineers formed the main topic of discussion. It seemed to be the concensus of opinion that the results of the work in this field are lamentably unsatisfactory, and there were experienced teachers present who maintained that not over ten per cent of those who had completed a course in calculus could make any appreciable use of what they had learned.

1. One tradition is that the calculus is essentially mysterious, alien to ordinary modes of thought and of such uncommon difficulty as to be accessible only to exceptionally gifted, not to say peculiarly constructed, minds, who alone can hope to acquire a command of it at all comparable to what they have of arithmetic or trigonometry. Even to good students there is about the subject a certain elusiveness with which it seems impossible to cope. After a year of conscientious effort the student is left with the uncomfortable feeling that all he has to show for his labors is a certain smattering of knowledge of little or no practical use. In the language of Sir George Airy, an experienced teacher of well prepared students: "The results of the differential calculus are received by many rather with the doubts of imperfect faith than with the confidence of rational conviction."

A similar view was expressed by the famous Augustus De Morgan, who wrote in his classical treatise: "It is a matter of common observation that one who commences this study, even with the best elementary works, finds himself in the dark as to the meaning of the processes which he learns, until at a certain stage in his progress, depending upon his capacity, some accidental combination of his own ideas throws light upon the subject. The reason of this may be that it is usual to introduce him at the same time to new principles, processes and symbols, thus preventing his attention from being exclusively directed to one new thing at a time."

The great Cambridge coach and eminent mathematical writer, Isaac Todhunter, in his well known textbook on calculus, says: "It frequently happens that a person commencing this subject is discouraged at the outset because he cannot discover or imagine any practical application of the somewhat abstruse points to which his attention has been directed."

2. Another tradition is that the calculus lacks those qualities of definiteness, precision and manifest logical consistency which are supposed to constitute the distinctive merits of mathematics. A further quotation from Todhunter will express very accurately the experience of many students of the calculus. "A difficulty of a more serious kind appears to embarrass many students of this subject, namely, a suspicion that the methods employed are only approximation, and therefore a doubt as to whether the results are absolutely true. This objection is certainly very natural, but at the same time by no means easy to meet, on account of the inability of the reader to point out any definite place at which his uncertainty commences."

This difficulty was keenly felt by such students as General Nathaniel Lyon, West Point '41, who gives vent to his disgust in this vigorous language: "The inventors of the differential and integral calculus have claimed that this branch of so-called science

belongs to the department of mathematics, and, laboring under the delusion have introduced it into the course of academical instruction for the torture of students. Such classification is obviously incorrect, because the principles of mathematics fall within the scope of the reasoning faculty. The calculus, on the contrary, lies without the boundaries of reason." An examination of the textbooks used in those days would go far to explain, if not to justify, this harsh judgment.

3. A third tradition is that the calculus has very limited professional utility. This contention is not without plausible support. In much of the work in design, the numerous excellent handbooks, rich in tabulated material, dispense to a great extent with the necessity for the direct use of the calculus by reducing the calculations to purely arithmetical operations. It is also true that men of the highest standing in the profession have had but little or no knowledge of higher mathematics and apparently have never been sensible of any loss in consequence. Trautwine in the preface to his famous handbook gives a list of helpful books on engineering, and then adds: "The writer does not include Rankine, Moseley, and Weisbach, because, although the books are products of master minds, and exhibit a profundity of knowledge beyond the reach of ordinary men, yet the language is also so profound that very few engineers can read them. The writer himself, having long since forgotten the little higher mathematics he once knew, cannot. To him they are but little more than striking instances of how completely the most simple facts may be buried out of sight under heaps of mathematical rubbish." This disdain of higher mathematics, so frankly expressed, is due in large part probably to the fact that the writer's acquaintance with the subject was at no time sufficiently thorough to admit of extended practical uses. Besides, the passage is sixty years old. During the intervening period the applications of advanced mathematics to engineering problems have been constantly gaining in number and importance.

III

These traditions are largely if not wholly rooted in a badly chosen starting point. In the textbooks the beginner is led at the outset into regions abounding in notions both novel and nebulous, in enigmas and obscurities, in symbols whose meaning is as hidden as the meaning of the words in Jabberwocker, and in operations contrasting sharply with his previous ideas of mathematical clarity, precision and rigor. He encounters quantities which behave in a most curious and unfamiliar way—functions which approach zero as a limit, fractions with vanishing numerators and denominators but

finite, may be large, quotients, magnitudes so small that Bishop Berkley christened them "ghosts of departed quantities," and orders of magnitude such that a magnitude of a lower order added to one of the next higher order leaves the value of the latter unaltered. Probably Dean Swift had these orders in mind when he penned the familiar gibe:

> "So, naturalists observe, a flea
> Has smaller fleas that on him prey;
> And these have smaller still to bite 'em
> And so, ad infinitum."

The difficulties of the customary modes of approach have been fully admitted by recent writers of textbooks on calculus and strenuous efforts have been made to minimize these difficulties and to render the path of the beginner smoother and more attractive, as may be seen by comparing Todhunter's famous work of sixty years ago with the more recent "Calculus for Engineers" of John Perry. American, English and German writers now follow Perry in the majority of cases, especially when preparing books for engineering schools. These efforts, however, are at best only meliorative and do not reach the real root of the difficulty. The student is still required to traverse a decidedly foggy stretch in passing from the quotient of increments to a quotient of differentials.

The difficulties felt by the beginner could be avoided in part, if not altogether, by a reversal of the customary order of presentation in the textbooks, and the adoption of a more arithmetical approach. Instead of starting with a study of the steps leading to the definition of the differential coefficient and the formulation of the rules for differentiation, a beginning could be advantageously made with an exposition of the differential coefficient and the formulated rules as distinct entities without regard, for the present, to modes of derivation. They are things to be explained and applied and not things to be derived and proved. The derivation and proofs have been provided long ago, and they are things which, provisionally at least, can be advantageously taken on trust. For the present our concern is to understand what they are and not how they have become what they are.

The more suitable form of the differential coefficient for a first approach is that of a fraction whose numerator and denominator are ordinary numbers, representing definite, measurable magnitudes. The distinctive character of this fraction as representing the instantaneous rate of change of one variable with respect to another can now be explained to a beginner in a way he can understand and appreciate. The rules for differentiation, based upon this conception of the differential coefficient, admit of easy explanation. This exposition should be accompanied with and followed by ex-

tended practice in the solution of illustrative problems of a practical sort, of which engineering provides a generous assortment.

IV

Several pertinent considerations in favor of this change of order readily suggest themselves.

1. This is the most intelligible and attractive phase of the subject. The student begins his work with a feeling that he is dealing with substantial realities and not elusive phantoms, which have grown out of attempts to explain and which contribute little directly to practical necessities. What is hazy in conception and obscure in theory is avoided. The abruptness of the transition from his previous studies is minimized. He is now performing operations whose meaning is intelligible and utility obvious. The real significance of the calculus and its practical value are impressed upon the mind at an early stage. The student gets almost at the start a foretaste of the rôle which the calculus plays in engineering. This reversal helps to ward off that vague and uncomfortable sense of unreality which often haunts the mind of the novice and creates a prejudice, not to say a certain repugnance, against the subject.

2. This order provides a favorable starting point for a study of the expedients and logical refinements employed in the derivation of the differential coefficient from the integral equation. It has been said that if we want to show the evolution of the herring from some simpler form, the best way is to begin with a study of the existing form and present habits. If we want to become familiar with the mechanics of the automobile, it is well to begin with a study of the mechanism and it would be no disadvantage to be able to drive. In like manner a sufficient knowledge of the rules of calculus to enable the student to apply them successfully to the solution of obviously worth while problems puts him in a good mood to attack more recondite phases of the subject, and especially does it relieve him of that enfeebling conviction that he has "no idea as to what it is all about." Furthermore, as a machinist picks up a good many useful mechanical ideas and scientific principles while working at his machine, so will a student of calculus catch valuable glimpses of underlying principles while making practical uses of the rules.

3. This inversion is accepted in other subjects, both as a rational expedient and a practical necessity. Students are taught the meaning and uses of logarithms and trigonometric functions long in advance of instruction in the underlying theory and the construction of tables. In the words of the late Professor John Perry: "It is pedantic to say that a man must not use a formula unless he is able to prove its truth. It is usually a great help in learning to prove a

formula to have previously used the formula and know the meaning and value of what we are to prove. A living Northern professor of great eminence has declared that a boy ought not to be allowed to use logarithms until he is able to calculate them; he has not said that a boy ought not to use a watch or to wear a coat until he is able to make them." The rules can be rationally adopted and confidently used because they form a substantial part of a great body of verified knowledge. A traveler who refuses to pass over a bridge the soundness of which he had not tested would not go very far. A boy who would not ride a bicycle or pitch a curved ball until he had mastered the dynamical principles involved would be in the class with the carpenter who would not use the Pythagorean proposition until he found his way back to the axioms. It is wise to take some things on trust even in mathematics.

4. This is the historic order. The rules of the calculus did not have their source in rigorous logic. In fact, they were used correctly and profitably for two hundred years before a sound logical foundation was provided. The formulators of the rules of the calculus were men of sagacious minds and close students of the changing phenomena of the visible world. Intuition and patient reflection upon variable quantity, physical and geometrical, played a far more decisive part in the formulation of the rules than rigorous logic. Confidence in the validity of the rules had its source in the undeniable correctness of the results which followed their application. The greatest masters have been those who make free use of guesses, hunches, divination and other non-logical processes. A correct instinct was at work in the mind of the gentleman in "The Autocrat at the Breakfast Table" when he remarked sagely that most mathematical demonstrations constitute "a pons asinorum over chasms which shrewd people can bestride without such a structure."

Even Newton himself had only very indistinct ideas in this connection. Or if he did he failed to transmit them to posterity. Among his successors one of the most eminent was Colin McLaurin, of McLaurin's formula fame. Yet of him Woodhouse wrote: "Of the commentators on the method of fluxions (the present calculus) McLaurin must be accounted one of the most acute and judicious, but in his Introduction he exhibits rather the exertions of a great genius struggling with difficulties than a clear and distinct account of the subject he was discussing." Until the days of Weierstrass and his school, who, about the middle of the last century, did much to straighten out the logic, the demonstrations of the rules of the calculus were, like the Englishman's metaphysics, "bad reasons for what we believe on instinct." Up to that time mathematicians were so occupied with the applications of the calculus that they treated the rules very much as an eminent English mathematician

treated those for imaginaries. "Whether I have found a logic by the rules of which operations with imaginary quantities are conducted is not now in question; but surely this is evident, that since they lead to right conclusions, they must have a logic."

5. In spite of the labors of Cauchy, Weierstrass and others of lesser note to put the calculus on a satisfactory logical basis, there are not wanting stout unbelievers who contend that a rigorous demonstration of the rules of the calculus is an inherent impossibility. So high an authority in the field of scientific engineering as Sir Oliver Heaviside commits himself to the opinion that for the past "twenty-five years we have erred in attempting to lead the student to a working knowledge of the calculus by first convincing him that the reasoning is sound. It is quite possible that the fundamental principle does not admit of deductive demonstration." As Comte advanced in life he seemed to become increasingly convinced that there is in the calculus a transcendental element which renders all attempted demonstrations alike irrational and futile. The laws of the calculus, like Newton's laws of motion, are to be accepted because in all their applications they are always found to agree with the facts of experience.

V

The primary interest of this paper is pedagogical rather than logical. That is, the chief concern here is not with a logical development of the calculus, but rather with the course likely to prove the most advantageous to the student to whom it is to serve as a tool in his professional work. It is the suggestion of the paper that the desired object can be most effectively achieved by following the principle of learning by doing. There is no intention of encouraging the substitution of shop methods for a thorough basal examination of the subject. In order to have a complete understanding of the calculus and in order to secure a mastery of its uses on the higher levels, the subject should be examined from the point of view of infinitesimals, limiting ratios, first derived functions, as well as those devices by which it is sought to avoid these more recondite aspects.

There is no suggestion in these paragraphs of a calculus made easy. There is no such calculus beyond the title page. The late Professor S. P. Thompson exercised to the utmost his superb genius for exposition in the preparation of the charming little book, "Calculus Made Easy." One does not turn many pages, however, before finding himself face to face with the same old difficulties which have been familiar to students from the days of Newton to the present time. If one will take stock of the mental activities required in the study of the calculus, he will readily satisfy himself that the

subject has no place in the list of easy courses. What is here suggested is that it can be made easier and more attractive to the ordinary student than it now is by concentrating attention and effort at first upon an interpretive study of the rules and practice in their varied applications to the solution of engineering problems. This working knowledge provides, as stated before, a good starting point from which to proceed to the study of the theoretical basis of the rules. In itself, however, even if inaptitude or disinclination should make it inadvisable to struggle with the more subtle phases of the subject, this practical acquaintance with the calculus is a valuable addition to the engineer's intellectual and professional equipment. And in cases of this sort it seems like an open question whether, from educational and cultural standpoints, a thorough command of a few working concepts and rules, reproducible at a moment's notice, are not preferable to a mass of ill-formed ideas admitting of no practical uses and not likely to outlive the embryonic stage.

VI

The teaching of calculus in American colleges falls into three fairly well-defined periods. The first covers roughly the first three quarters of the 19th century. During that period we were plain imitators and translators, depending largely for our ideas upon British and French sources. The texts abounded in misty notions, faulty logic and barren abstractions. There was an utter absence of any concrete material to assist the student in forming any sort of an idea of what the subject was about; nothing to suggest any connection with physical or technical problems, although during all that period the calculus was applied with great success to astronomy, mechanics and engineering. The student was left to struggle with symbols and with operations, of the connection of which with sensible objects he had no conception whatever. It was a required study and enjoyed a great reputation as a source of mental discipline, as well as of perplexity and uncertainty. Among the texts used during a good share of this period were those of Davies and of Church, which are largely forgotten now.

The imitation stage was followed by what may be called the rigorous stage, in which the chief emphasis was laid on the rigorous demonstration of the fundamental proposition of the calculus. This stage was ushered in by the opening of Johns Hopkins University in 1876, by the return to this country of Sylvester after an absence of thirty years, by the migration of a large number of American graduates to Germany for advanced study and their return to professorial positions at home, and by the rise of the critical spirit in all branches of learning. The influence of Weier-

strass and his school was particularly felt in the treatment of the calculus. The older texts with their crude and often erroneous methods found their way into the discard, to be replaced by those in which the logic was at least meant to be irrefragable. One text, quite typical, written especially for engineers, devotes nearly a whole page of closely printed matter to the derivation of the rule for the differentiation of the product of two variables. The page presents a pleasing appearance to the eye, for the symbols are very tastily arranged, but how far the page is a source of light and leading to the sophomore is at least a question. Another very able work, of the same period, devotes several pages to the derivation of the differential coefficient of a logarithm. All may be very admirable mathematics, but it is certainly very questionable pedagogy. Whatever success may have attended efforts on the score of logic, the benefits of rigor were not widely diffused and the calculus continued to be to the great majority of students a terra incognita, and its value in practical affairs unappreciated. The difficulty in accepting the logic of the first period was more than offset by the impossibility of understanding the logic of the second period.

About thirty years ago we seemed to enter upon a third stage, marked by the placing of the principal emphasis upon reality rather than upon rigor. Efforts to make the processes logically rigorous are giving way to efforts to make them real, vivid and vital, and therefore attractive, in the very rational expectation that this is also the surest path to whatever certainty along this line that is accessible to finite understanding. Reliance is put increasingly upon intuition, judgment, exposition and close touch with visible reality. Concrete problems are used in increasing numbers, and there is a practical acceptance of the principle that in the acquisition of knowledge an idea is best grasped when given a visible representation. In recent texts practical problems drawn from engineering sources abound, but the attempt to demonstrate the principle of the calculus deductively has not been wholly abandoned in favor of a purely expository method. We are still in the clutches of the old idea, from which no author has been able to break away to the extent of putting instruction in differentials on the same footing as instruction in logarithms, trigonometric functions, and components of forces.

In these three stages there is, naturally, considerable overlapping. Adumbrations of the present attitude and methods are clearly discernible as far back as the early forties, when Professor Elias Loomis published the first edition of his calculus. Though he, primarily a physicist, had a keen sense for the concrete and practical, he confines himself to illustrative problems of a geometrical character. It was only in a much later edition, under the influence of

Professor H. A. Newton, an astronomer, that he introduced problems from mechanics. The inspiration and model for this work came from an earlier book on the subject by Professor William Ritchie of University College, London, which, by the way, was a work of exceptional merit considered as a textbook. Professor Edward Olney, in the early seventies, published a book on calculus in which kinematic problems were freely used. This work embodies the instinct that had been working in the minds of the teachers of this subject for some years. It was severely criticized at the time of publication because of its adoption of the infinitesimal method. About the middle of the 19th century we had two mathematicians in this country who were in no sense passive imitators in this matter but active and original thinkers—Professor Benjamin Pierce of Harvard and Professor Theodore Strong of Rutgers, the former ably expounding the infinitesimal method of Leibnitz and the latter the purely algebraic method of LaGrange.

A STUDY OF SOME OF THE PHASES OF SHOPWORK AS A PART OF PROFESSIONAL ENGINEERING

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INTRODUCTION

The study of professional engineering shop first entails an understanding of engineering objectives; then a knowledge of the present status of the shop laboratories; next, a study and a decision as to whether they are necessary as a means in fulfilling the engineering objectives; and, finally, if found necessary, to determine what manner of shop must be organized and given to help fulfill these objectives. The term shop as used throughout this study refers to the educational content given in such courses, as commonly referred to as machine shop, heat treating, welding, and the like. It may be an engineering shop in which the work may be of the trade type, or it may be one of the strictly engineering laboratory type, where the engineering aspects rather than the trade aspects are emphasized.

Meade says that the field of engineering work includes those branches of technical service and of business and professional work which have to do with the utilization of natural resources for human benefit. The function of engineering service is the adaption of the laws and resources of nature to utilitarian purposes. It involves the active utilization of natural conditions and natural resources through construction.

The aims of professional engineering are sometimes given: first, as the control of nature; second, as the direction of men; third, as the appraisal of values.

The functions of the engineer become; first, the designer; second, the supervisor; third, the constructor; fourth, the operator; fifth, the investigator; and sixth, the adviser. It is the engineer's duty to formulate an ideal and from that ideal, to create a reality.

The engineering colleges are educating for the field of engineering work. They are training young men to satisfy the aims of professional engineering and to perform the various functions of the engineer. Does so-called shopwork have a part, and if so, what part in educating for the above field, and in training for the above functions?

The purpose and scope of this investigation is determined by the preceding question, and by the various conditions which seem to exist in engineering colleges in the field of professional engineering shop. Conditions which prompted the study are as follows:

1. Variation of opinion.
2. Attitude of faculties.
3. Attitude of students.
4. Very few previous studies.
5. Haphazard growth from the mechanics colleges of earlier days.
6. Comparison of vocational and industrial shop education of the secondary grade with the shop of the so-called professional engineering grade through personal observations.

The prime purpose of this study then becomes that of getting the desired knowledge of the present status of engineering shop, and from this study and the engineering objectives, to find a solution as to the place of shopwork in the curriculum if it should have a place, and to determine what manner of shop should be organized and given.

To make certain that the statistical results are reliable, practically the whole population from a statistical point of view has been studied. Therefore the difficulties of random sampling have been largely eliminated. From this total population there has been a return of nearly 70 per cent. The investigation covered 109 schools which were selected after semi-technical schools and a few engineering departments of little importance in this study were eliminated. The 109 schools were divided into 2 groups; those with shop and those without shop as determined by their catalogues. About 4/5 of the group had shop of some nature and the other 1/5 had no shop. There has been an average return of 4 replies per school. Following tables show the excellent distribution of the replies over these 109 schools, every school responding. These 109 schools cover every section of the country, every possible environment, and every size of school giving four year courses. Deans, Department Heads, and Superintendents of Shops were included in the survey. Also to make the picture as complete as possible 18 industries, all large employers of engineering college graduates were asked for their ideas on the subject. The replies give industry's point of view in so far as these industries are concerned. The replies from industry have come from Vice-Presidents, Works-Managers, Educational Directors in industry, and the like.

Four sources of data and information were used in gathering complete facts. These 4 sources were; engineering and college catalogues, the college bluebook, past literature on the subject, and most important, the questionnaire sent to all the schools.

A straight tabulation of the data received was made. The returns named those administrators who in the main decided what shop should be given for each curriculum. These replies were totaled to give the final consolidated results in regard to what shop should be given in each curriculum. Each group of department heads vary very little from the total results as given.

Statistical Results

The following tables give the statistical results.

TABLE 1

Average Hours per Week for One Semester

(Represents total shop given as taken from the catalogues of the 109 schools studied, reduced to a semester basis and clock hours per week.)

	Wood	Pattern	Foundry	Forge	Heat Treat.	Weld.	Mach.	Total
Mechanical Engineering	1.1	2.7	2.8	3.1	.4	.1	8.9	19.1
Electrical Engineering	1.0	2.5	2.1	2.1	.1	.1	6.2	14.1
Civil Engineering	1.1	1.0	.7	1.4	.1	.07	1.1	5.4
Chemical Engineering	.6	.8	1.1	1.2	.03	0	1.6	5.3
Mining Engineering	.9	.1	.9	.9	0	.04	1.2	4.0
Industrial Engineering	.9	1.2	2.1	1.0	.5	0	6.8	12.5
Arch. Engineering	.9	0	.25	.6	.05	0	.05	1.8
Ceramic Engineering	.4	0	.9	0	0	0	0	1.3
Metallurgical Eng.	.7	0	1.0	.8	.12	0	1.2	3.8
Petroleum Eng.	.75	0	0	.75	0	0	0	1.5
Textile Engineering	1.4	0	.3	1.1	0	0	5.4	8.2
Sanitary Eng.	.75	0	.75	.75	0	0	0	2.2
Aero. Engineering	.4	3.4	2.9	2.7	5.2	0	5.2	14.8

TABLE 2

Returns—Schools without Shop

	Sent	Returned	Per Cent
Deans	22	15	68.2
Mechanical Engineering	17	11	64.7
Electrical Engineering	21	13	61.9
Civil Engineering	22	13	59.1
Chemical Engineering	16	12	75.0
Mining Engineering	6	5	83.3
Industrial Engineering	5	3	60.0
Petroleum Engineering	2	2	100.0
Totals	111	74	68.2

TABLE 3

GEOGRAPHICAL DISTRIBUTION OF RETURNS—SCHOOLS WITHOUT SHOP

Region	States	Schools	Returns	
Pacific Coast	1	1	5	
Rocky Mountain	1	1	4	
Middle West–West	1	1	2	
Middle West–East	2	4	14	Avg. 3.5
South Mississippi	1	1	1	
Southeast	3	4	12	Avg. 3.0
East	5	7	25	Avg. 3.6
New England	3	3	11	Avg. 3.7
Totals	17	22	74	Avg. 3.4

Average means average per school.

TABLE 4

DISTRIBUTION OF SCHOOLS ACCORDING TO THE NUMBER OF REPLIES AND THE NUMBER OF COURSES PER SCHOOL—SCHOOLS WITHOUT SHOP

Number of Replies	Schools	Per Cent
1	2	9.1
2	2	9.1
3#	8	36.3
4#	6	27.3
5#	4	18.2
Totals	22	100.0

Number of Courses	Schools	Per Cent
1	0	0.0
2	1	4.6
3#	8	36.4
4#	5	22.7
5#	5	22.7
6	3	13.6
Totals	22	100.0

The symbol # marks those numbers which occur the most; indicating a well balanced distribution of replies with reference to number of courses offered.

TABLE 5

RETURNS—SCHOOLS WITH SHOP

	Sent	Returned	Per Cent
Deans	87	64	73.6
Mechanical Engineering	84	58	69.0
Electrical Engineering	80	61	76.3
Civil Engineering	80	55	68.7
Chemical Engineering	63	45	71.4
Mining Engineering	28	19	67.9
Industrial Engineering	16	10	62.5
Architectural Engineering	21	15	71.4
Ceramic Engineering	6	5	83.3
Petroleum Engineering	2	1	50.0
Textile Engineering	4	3	75.0
Sanitary Engineering	2	1	50.0
Aeronautical Engineering	6	4	67.7
Superintendent of Shops	80	39	48.7
Industrial Section	18	15	83.6
Totals	579	397	68.6

TABLE 6

GEOGRAPHICAL DISTRIBUTION OF RETURNS—SCHOOLS WITH SHOP

Region	States	Schools	Returns	
Pacific Coast	3	6	31	Avg. 5.1
Rocky Mountain	7	9	33	Avg. 3.6
Middle West–West	8	14	77	Avg. 5.5
Middle West–East	5	13	59	Avg. 4.5
South Mississippi	6	11	47	Avg. 4.2
Southeast	7	9	39	Avg. 4.3
East	6 and Washington, D. C.	17	65	Avg. 3.6
New England	5	8	31	Avg. 3.9
Totals	47 and Washington, D. C.	87	382	Avg. 4.4

TABLE 7

DISTRIBUTION OF SCHOOLS ACCORDING TO THE NUMBER OF REPLIES AND THE NUMBER OF COURSES PER SCHOOL—SCHOOLS WITH SHOP

Number of Replies	Schools	Per Cent
1	2	2.3
2	8	9.2
3#	14	16.1
4#	19	21.8
5#	26	29.9
6	11	12.6
7	7	8.1
Totals	87	100.0

AA

Number of Courses	Schools	Per Cent
1	1	1.1
2	0	0.0
3#	14	16.1
4#	33	34.5
5#	17	21.8
6	20	24.2
7	2	2.3
Totals	87	100.0

The symbol # marks those numbers which occur the most; indicating a well balanced distribution of replies with reference to number of courses offered.

TABLE 8

INSTRUCTIONAL AIDS BEING USED

	Text	Notes	Ref. Work	Reg. Lectures	Practical Instruction Sheets
Pattern	10	12	8	14	15
Foundry	12	11	10	10	10
Forge	7	9	5	11	11
Machine	16	15	13	18	18
Heat Treat	8	12	11	11	11
Weld	8	13	7	9	9
Production	5	6	6	6	6

Trips, lantern, special demonstration were mentioned. Total returns for above were (*39*).

TABLE 9

MAXIMUM NUMBER OF STUDENTS PER CLASS PER INSTRUCTOR

Pattern	20–25
Foundry	15–20
Forge	15–20
Machine	20–25
Heat Treat	10–15
Weld	15–20

Classes in general were less than the figures given, being limited by lack of room and equipment. These figures are for shopwork as now given.

TABLE 10

FROM REPLIES FROM MEN IN INDUSTRIES

From 15 of the Large Employers of Engineering Graduates.

		Yes	No
I.	Should shopwork be given in any professional engineering course?	13	2
II.	Should shopwork be given in all courses?	9	–
	(Should be given in M.E., E.E., Ind.E., C.E.)	1	
III.	Purposes given:		
	1. Study of Materials		
	2. To give a practical point of view		
IV.	Are these courses the same value as other courses?	7	3
V.	Should the shops have direct contact with industry?	7	2
VI.	Are the shops one of the best means of coördinating industry and the schools?	6	2

TABLE 11

CONSOLIDATED GENERAL STATISTICAL SUMMARY

			Yes	No
I.	Should shopwork be given in a professional engineering course?	(1)	339	119
II.	Should summer shop in industry be required?		125	219
III.	Is the program so arranged that shop objectives are put into use?		205	41
IV.	Should other than mechanical engineering students take shop?		267	22
V.	Is shopwork considered of commensurate value with other courses?		150	76
	a. By the faculty		161	86
	b. By the students	(2)	131	90
	c. By the graduates		115	68
VI.	Is there any connection between shop and the other work in the curriculum?	(3)	130	101

TABLE 12

SHOP PURPOSES

1.	Skill of Hand	101	
2.	Appraisal of Values	98	
3.	Knowledge of Materials	241	(1)
4.	Training of Judgment	144	
5.	Knowledge of Design	169	(2)
6.	To illustrate fundamental principles of engineering	156	
7.	Knowledge of Production and Manufacturing	162	(3)
8.	One of the laboratories to apply principles of academic work	103	

Those shop purposes which might be classified as giving formal disciplinary values and not direct values are not considered of the same importance as those giving direct values. According to the latest educational psychology, formal discipline as exemplified by training of judgment is extremely questionable. Such training as received like that mentioned above, would only train shop judgment; and since some, or it may be said perhaps the majority of shops are

far enough removed from industry, that even little such training is actually transferred from the school shop to the industrial shop where it would be used in life situations. To be effective there must be life situations.

TABLE 13

CONSOLIDATED TABLE OF INDIVIDUAL SHOPS FOR EACH CURRICULUM

	M.E.		E.E.		C.E.		Chem. E.		Min. E.	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Pattern	114	21 (R)	111	70 (R)	34	133	38	105	30	110
Foundry	124	16 (R)	122	66 (R)	43	120	60	97	45	94
Forge	109	28 (R)	112	68 (R)	54	112	52	103	62	79(E)
Machine	136	6 (R)	174	14 (R)	53	113	76	83(E)	59	78(E)
Heat Treat	116	24 (R)	100	90 (E)	36	130	64	94	54	84
Weld	114	27 (R)	110	73 (R)	51	117	55	102	49	93
Production	64	?71	44	133	14	133	7	143	5	130

	Ind. E.		A.E.		Met. E.		Tex. E.		Cer. E.		Aero. E.	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Pattern	84	54 (R)	38	99	–	3	1	3	–	4	2	1
Foundry	92	41 (R)	42	94	2	1	0	4	1	3	3	–
Forge	80	51 (R)	41	95	2	1	1	3	–	4	1	2
Machine	97	35 (R)	43	93	1	2	4	0	1	3	3	–
Heat Treat	83	49 (R)	37	100	1	2	0	4	–	4	3	–
Weld	82	52 (R)	41	93	1	2	1	3	1	3	3	–
Production	74	?55	13	116	0	3	1	3	–	4	1	2

(The number of schools giving last 3 curriculums is not great.) (Metallurgy seems to be generally combined with mining or chemistry.) Check to determine significant differences is below.

Cases	Numerical Difference	Per Cent of Total	Difference Per Cent	Probable Error in Difference	Chances in 100 for a True Difference
FOR TABLE 11					
(1) 458	220	26	24	.025	100
(2) 221	41	41	9	.0318	98
(3) 231	29	43	7	.0314	93

For Table 13

M.E., Min.E., Ind.E., A.E.

125	25	40	10	.0423	95
125	46	33	17	.0414	100

E.E., C.E., Chem.E., and others

150	30	40	10	.0423	96
150	55	33	17	.0378	100

Differences are not checked where the number of cases is less than 25.

Those shops with the differences significantly in favor of shop are marked with an (R) for the required shop and where the difference is not significant in either direction, the shop is marked with an (E) for elective. Those not marked at all are to be omitted as the difference is significant and opposed to the shop. The preceding represents the best composite opinion of nearly 75 per cent of the administrators of the engineering schools, and includes schools with and without shop.

TABLE 14

Consolidated Shop Combinations

Mechanical Engineering	
All courses as listed	43
All courses except production	36
Patt., fdry., fge., mach., heat treat, weld	4
Foundry, fge., mach., heat treat, weld	5
Electrical Engineering	
All courses as listed	19
All courses except production	17
Pattern, fdry., fge., mach.	14
Machine only	3
Civil Engineering	
All courses except production	2
Pattern, fdry., fge.	3
None	28
Chemical Engineering	
All courses except production	5
Fdry., fge., mach., heat treat, weld	3
Mach., heat treat, weld	3
Machine only	5
None	24
Mining Engineering	
All courses except production	7
Fdry., fge., mach., heat treat, weld	6
Fge., mach., heat treat, weld	3
None	25

Industrial Engineering	
All courses as listed	37
All courses except pattern	9
None	12
Architectural Engineering	
All courses as listed	7
None	41

(A.E. may have been taken for aeronautics in a few cases; however it does not affect the results.)

All other combinations appeared less than 3 times.

TABLE 15

COMBINATIONS SELECTED FOR CURRICULUM COURSES

Mechanical Engineering	
All courses with not more than 1 omitted	85
All others	32
Electrical Engineering	
All courses with the omission of any except pattern, foundry, forge, machine	60
All others	41
Civil Engineering	
None or not more than 1 course	68
All others	35
Chemical Engineering	
None or not more than 1 course	47
All others	41
Mining Engineering	
None or not more than 1 course	37
All others	33
Industrial Engineering	
All courses with not more than one omitted	50
All others	24
Architectural Engineering	
None or not more than 1 course	51
All others	22

TABLE 16

SHOP CONTROL TABLE

Title and rank of man in direct control shops	
1. Instructor	35
2. Superintendent of Shops	32
3. Professor	28
4. Head of Mechanical Engineering	28
5. Assistant Professor	23
6. Associate Professor	6
Title and rank of man who controls the shop situation	
1. Dean	35
2. Head of Mechanical Engineering	32
3. Head of department concerned	30
4. Committee or faculty	23
5. Professor of Mechanical Engineering	12
6. Dean and Head of Mechanical Engineering	3

Pertinent Quotations and Suggestions Received; the First Series Without Shop, and the Second Series With Shop

In order to show what many engineering educators and some industrial leaders have in mind in the field of engineering shop, the following quotations are given. These statements also help to show the variety of opinion. In many cases they contain helpful suggestions. They are a random selection. They also furnish added data or information which forms part of the background for recommendations.

A. Without-Shop Series

1. *The Deans' Section*

1. May have some practical value but believe that the time could be better spent on theoretical subjects.

2. Too expensive, almost impossible to keep equipment up-to-date, equally difficult to keep processes up-to-date.

3. Shopwork is of high school grade; manual work should be taught in the high school; the college should maintain all kinds of laboratories but not practice shops.

4. Require for entrance or have the technical high school give it in the summer. Too time consuming for a 4 year course.

5. We see no reason for considering this subject any different than any other course in the curriculum. On this basis it should be treated by lecture and text book, with the additional opportunities as may be available.

6. I favor short intensive courses during the summer.

7. The time should be spent on fundamental subjects, there is too little time available now for the four year course.

8. More physics, more chemistry, design, economics, accounting, liberal arts might be substituted for shopwork.

9. While shop knowledge is useful it must be obtained before college or in some intensive way.

2. *Mechanical Engineering Department Section*

1. Time of student should be put to the best use on studies he can not so well pursue outside of college. Shop is better obtained in the summer and after graduation than ever in school. Too expensive to keep equipment and methods up-to-date.

2. A large number of boys can get shop in technical high schools; required to have six months experience before graduation.

3. Can get shop during the summer or after graduation very quickly. Can use the time to better advantage.

4. Should be given in industry.

5. Good courses in various engineering laboratories could replace shops.

6. In my opinion a certain amount of shop training under a competent teacher is a very valuable piece of engineering training.

3. *Electrical Engineering Department Section*

1. Limit the amount to the minimum amount required to acquaint students with tools and processes.

2. Time during the college semester is too valuable to be dallied away in shopwork. Those who intend to go into mechanical engineering or electrical engineering should be sufficiently interested to get shop outside of school.

3. Shopwork in industry is much more profitable.

4. Time can more advantageously be spent in other kinds of instruction.

5. Cognizance of the ability of the student to keep in touch with practical engineering should be taken.

6. There should be more electives outside of engineering.

7. I believe shopwork gives the student something which cannot be obtained elsewhere. For the designer it is necessary. Sufficient work can be given. Success or failure will be determined by the planning of the work.

4. *Civil Engineering Department Section*

1. Space and equipment are too costly; industrial plants are training graduates along shop lines to a better advantage than the schools.

2. Coöperative system of education seems to be the best and modern method of engineering education.

3. In a brief four years there is more important material needing study than the shop courses. Better spend more time on the social sciences.

4. Depends upon the nature of the course.

5. There is no need for shop in civil engineering and it is of doubtful value in other courses.

6. Nothing can replace shop.

7. Require at least two summers of practical work along the lines of the course taken.

8. One of the most valuable courses taken as a student.

5. *Chemical Engineering Department Section*

1. Collegiate education can only stress the fundamentals in this vast subject. To aid adequately too large an investment in equipment would be required.

2. Other activities are more beneficial.

3. There is not enough time.

4. I prefer shop in the regular schedule and six weeks factory work in the summer.

5. Shop should not be given at the expense of fundamental subjects.

6. Personally I think shopwork has little place in an engineering course. Very useful but not a part of engineering education.

6. *Mining Engineering Department Section*

1. There are more important subjects to the mining engineer which are omitted because of lack of time.

2. Actual work on the job is better.

3. I feel strongly in favor of this as colleges can do much to bridge the gap which now exists between the so called fundamentals and their actual application. Certainly shopwork is one of the best places to bring about a connection.

4. I believe that every young man going into engineering should have some shop experience either before or after entering college.

5. There seems to be no good reason to include shop in mining engineering to the exclusion of more necessary subjects.

7. *Industrial Engineering Department Section*

1. We have no shops; I think we should.

2. We strongly advise our students to take up summer work in the industry in which they are most interested.

3. We are short of time for intellectual development.

8. *Petroleum Engineering Department Section*

1. Already filled with required subjects and too inelastic.

2. Have field work in the oil industry.

B. With Shop Series

1. *The Deans Section*

1. In general I believe too much emphasis has been given to shopwork, and possibly the kind of work given has not been of the best. On the other hand to eliminate them entirely would be a serious mistake.

2. Do not think industrial shops are a full substitute.

3. Nothing takes the place of shop laboratories for instruction and experimental phases. No school shop can show varied applications like industry can. A combination of the two is the only solution.

4. Think shop is desirable.

5. Don't replace them.

6. Nothing can take their place.

7. I am strongly of the opinion that the time of students is too valuable to be spent in shop—it is impossible to have the tools or methods of industry, and when that is admitted the argument for shop falls, because they have learned something of no practical value.

8. Suggest in place of shop a shop "clinic" demonstrated lectures with notes and collateral reading with shop time reduced to one period per week.

9. Would suggest better shops.

10. I believe the time is coming when state schools will have to take over the function of semi-technical education.

11. Not long ago, I was in a certain college machine shop that looked splendid to me. There were perhaps 50 machines of various kinds. A gentleman, an alumnus of the college, was with me. I said it looked nice. The reply was, "Oh yes, but I happen to be in that business and there is hardly a machine that would be tolerated in any plant. They are all antiquated."

12. We are of the opinion that shop should be used to illustrate production problems and to aid in developing an appreciation of the relation between design and manufacturing processes.

2. *Mechanical Engineering Department Section*

1. The pattern shop has been eliminated and only a few representative machines have been retained. Similarly only typical machine tools, illustrating shop methods, time study, and materials handling will be used to illustrate this phase of machine shop practice.

2. We believe that students learn about 3 times as much about patterns as we now teach it than when he did the manual work in the laboratory.

3. Would suggest nothing in place of the shop laboratories.

4. Nothing should replace the shop laboratories.

5. Summer courses in industry might replace shop but they are hard to arrange.

6. Would suggest more work in metallurgy.

7. Work in industry might be better if it could be chosen and directed.

8. Every student should engage in some outside technical employment during his summer vacations.

9. The shops are made the center of a group of student self-help industries employing student labor.

10. The foundry is run about 2 months a year on strictly production.

11. There is not the correlation there should be between shop and the other work in the curriculum.

12. The student should not receive instruction detrimental to his ambition to study theory.

13. Shop instructors should be technically trained men.

14. Some effort is being made towards methods of procedure and away from mere exercise work.

15. It is possible that the entire method will be changed so that shopwork will be combined with metallurgy and materials testing, thereby comprising a comprehensive course.

3. *The Electrical Engineering Department Section*

1. More time should be spent in science and mathematics, and their application.

2. There is no equivalent possible.

3. Shop should be given to students who have not had the equivalent elsewhere. If the student cannot get shop in summer employment, an opportunity should be given at the university as an extra subject.

4. More time should be spent on fundamentals.

5. All engineering students should have a working knowledge of different types of standard commercial machines as found in machine shops in order to be able to direct repairs, design, and construction of a varied nature.

6. We believe in shop experience in school and in industry.

7. A real difference of opinion exists as to the value of shop courses. It is safe to say that many of us outside of the mechanical engineering department are 'on the fence.'

8. The question of commensurate value is a hard one to answer. A few students are shop men. Except for mechanical engineering I do not think that the faculty pays much attention to the shopwork. Shop instructors are not college graduates.

9. I believe some shopwork is necessary to compel coördination of hand and mind. Universities are prone to the giving of trade school shop courses. The trade schools want to move into the university class. Each should stick to its own field.

10. Am in favor of shop when the emphasis is placed on the engineering aspects instead of skill.

11. Too much detail is paid to details pertaining to manual dexterity and not enough to the problems pertaining to the relation between production and design.

12. Students often complain that the material content is too low; that there is not enough education per hour spent in the shops. This can be controlled by the nature of the work given. Turning down a long shaft for instance involves little education after the first few minutes of the operation.

13. Instructors are just practical mechanics.

14. As now taught shop is of little value because here as in most engineering colleges the old type of instruction is given.

15. I am enthusiastic about shop as training for all engineering.

4. *The Civil Engineering Department Section*

1. Should give courses which have a more direct training or engineering value to the student.

2. Nothing should nor can replace them for the purpose they serve.

3. There are dozens of better subjects for civil engineers.

4. I know of no proper substitute for them.

5. There are so many subjects more important to the civil engineer and any of them would do.

6. We do not require shopwork in our civil engineering and have not for years. I'll admit I'd like the fellows to have it but I believe other things are more important for the work they are going to do.

7. I had no shopwork of any kind and often feel the lack of it. I am not sure but what our students get a little training in shop that they never get elsewhere and believe it is good for them.

8. We used to require certain shop courses. We came to the conclusion that these were of little value to the civil engineer.

9. I would make shopwork optional for all except mechanical and electrical engineering.

10. We have had a full curriculum for the last 10 years without it.

11. There should be a well defined connection between the shops and the other work in the curriculum.

12. We do not require shopwork in either sanitary or civil engineering.

5. *Chemical Engineering Department Section*

1. They have the notion that shopwork is to teach a man to run a lathe or forge or something like that.

2. If shopwork were eliminated its equivalent should be embodied in chemical engineering laboratory.

3. Shopwork should be required for entrance credit. More time should be given to fundamental science and engineering.

4. A technical man should be able to construct his own apparatus if necessary. Should be able to supervise the work of others.

5. Shopwork is not included nor is value of shop as important as many other subjects that can not be included because of lack of time.

6. We would give more shop if time were available.

7. Our experience has been that the chemical engineer needs shop less and less.

8. Shop is all right if in the hands of competent teachers.

9. If students learn nothing else than the proper care of tools, shop is worthwhile.

10. Always one may expect an objection to be raised to a course calling for manual labor. But it is nevertheless and for that, my reason, of value.

6. *Mining Engineering Department Section*

1. When we altered our course 3 or 4 years ago, we cut out shop entirely—we did not feel we could give the most essential subjects the time they needed.

2. I think shop is desirable. We included it until a few years ago it was dropped to lighten the schedule.

3. Fundamentals should be given in place of shop.

4. It is considered a desirable elective.

7. *Industrial Engineering Department Section*

1. We try to coördinate shopwork with the other work in every possible way.

2. There is nothing that can take the place of them in imparting the fundamentals of manufacturing.

3. Many opponents of shop instruction fail to realize its intangible values and aid in grasping other subjects.

4. There is no substitute.

5. I have many times heard important employers say they like our graduates because they are so practical which undoubtedly applies to other schools giving shopwork.

8. *Architectural Engineering Department Section*

1. The students are not required to take shop and I do not feel any necessity for the same.

2. It would be of doubtful value.

3. Materials testing is the only thing that might be given to architectural engineers.

4. I fail to understand why college credit is given for shopwork. Most of the courses can be taught in a vocational high school.

5. We have not required shop courses for years.

9. *Ceramic Engineering Department Section*

1. I doubt if work equivalent to the college shops can be had in the summer.

2. We require no shop in ceramics.

10. *Metallurgical Engineering Department Section*

1. For metallurgy I think shop should be required.
2. Much use is made of our shop laboratories in research work.

11. *Superintendent of Shops Section*

1. The chief argument in my opinion for the retention of shop in American colleges appears to be the general lack of any kind of engineering experience of the average college boy.

2. My opinion of shopwork is that we should have but 2 divisions and should call them wood trade and metal trade. Under each we should subdivide according to present day industry.

3. There is considerable difference of opinion amongst students and faculty as to the value of shopwork. If carried out at all, it should be done very thoroughly.

4. Shop laboratory is essential to the training of engineers. It is the type of laboratory that is important.

5. It is often true that the laboratory work instead of being definitely outlined to teach particular principles is dependent upon the experience and training of the individual who is head of the department.

6. It should be possible to attain a higher rank.
7. Considerable commercial work is done by the shops.
8. Let's improve them but keep them.
9. All engineering graduates should be handy with tools.

12. *Industrial Concerns Section*

1. Personally I feel very positive that shop should be retained as a part of professional engineering. I believe that an engineering education should be a solid foundation of science and mathematics, combined with a physical capacity to do good work and a character to direct the whole toward a definite ideal or objective.

2. Generally speaking I would give a certain amount of shopwork to all engineering students. It furnishes a series of practical situations which call for accuracy and neatness, competence, and an appreciation of skill even if not skill itself.

3. On the whole I think the great advantage of shopwork is that it gives a practical point of view which is a salutatory thing to have along with the great amount of theoretical training which of necessity makes up the schedule.

4. The greatest handicap of a professional engineer is the fact that he has not had practical work.

5. I don't see how anything else can take the place of shopwork.

6. The shops are the only place where a man can get a real value of time and labor.

7. Better coördination is brought about through the proper selection of instructors and Professors, selecting those who have had considerable practical experience.

8. I think shop courses if properly given are of the same value as other courses.

9. Too great a percentage of engineering graduates do not know how to work.

10. A theoretical engineering course would not turn out a practical engineer who can talk the language of the fellow with whom he must deal.

11. Nothing can equal shop training in value to the student.

12. Anything that you can do to give him this experience will work to the advantage of the student and industry.

13. Shopwork need not be given in an official engineering course, though it is exceedingly desirable as a summer experience or as a part of graduate training.

14. The student should take shopwork as early as possible in his studies.

15. Most of our people who are in touch with educational work feel that shopwork in the college is not especially profitable.

16. It is especially difficult for Professors in engineering colleges to keep abreast with developments in industry and it is practically impossible for them to appreciate the necessity of production meeting schedule dates, and securing workable results. A man who does not have this point of view can not teach it to others.

17. I believe all engineering students should have shop but should have less of the old time trade training that was common in technical schools 15 or 20 years past.

18. The shops should provide a laboratory where the student can crystalize his ideas as to the practical applications of his engineering education.

The above comments come from men in industry who are Vice-Presidents, Works Managers, Educational Directors, and the like.

The men in industry are in the practical work. Naturally they are inclined to emphasize the practical. The men in college are to a large extent giving theory and are more academic minded. Many of the latter have a practical viewpoint and many do not. Those inclined towards theory think theory should be given. Industry gets the graduate and finds that he is unable to apply his theory to the job. They favor more practical work. The writer agrees with the men in industry. There should be plenty of theory but that theory in order to be of the most benefit to the student must be used by him in actual life situations that should be produced in his college course in the various subjects.

While all the preceding quotations may show a wide variation in

opinion, it must be kept in mind that these quotations have no connections with numbers actually in favor of a certain point. There may be very few or there may be very many in favor of a certain point. The statistical tables give the numbers for or against certain major propositions.

Summary and Conclusions

The following conclusions are drawn from the data.

1. It appears that engineering educators believe that there are valuable contributions to engineering education contained in shopwork, and that it should not be dropped from the curricula.
2. Summer shopwork while desirable should not be required.
3. Very little has been done in the semi-technical field which includes training for chemists, draftsmen, and the like.
4. The following should be shop purposes for all courses giving shop unless excepted.
   a. To give a knowledge of materials.
   b. To give a practical knowledge of design.
   c. To give a knowledge of production and manufacturing.

Exceptions:

Chemical Engineering.
   a and *b*. As above.
   c. To develop skill of hand.

Industrial Engineering.
   a. As above.
   b. To produce illustrations and applications of principles of academic work.
   c. To give a knowledge of production and manufacturing.

5. Other than mechanical engineering students should take shop.
6. Shopwork in the majority of cases is considered of commensurate value (if properly given) with other courses. However the attitude of the students seems to be less favorable than that of the faculty and graduates.
7. There seems to be quite a lack in connection between the shops and the other work in the curriculum.
8. Objectives appear to be partially put into use.
9. Full use of the various instructional aids is not made. The use of any particular type is small.
10. Lack of equipment and of room is the most common factor in determining class size.
11. The industries replying were, as a group, decidedly in favor of shop.
12. Evidence points to the fact that there should be a desirable amount of shopwork in mechanical, electrical, and industrial engineering. It also points to the fact that there should be very

little or no required shop in civil, chemical, mining, and architectural engineering. Metallurgy appears to be in the same class as mining and chemical engineering. Ceramics is in the same class as civil engineering, and textile and aeronautical engineering seem to line up somewhat with the first mentioned group in that some shop should be required.

Discussion of Results

The data unquestionally point to the fact that there are valuable contributions to engineering education contained in shopwork, and that it should not be dropped from the professional curricula.

A knowledge of this field is necessary if engineering objectives are to be fulfilled. Utilization of natural resources means change of state, means manufacturing with all of its ramifications, means a thorough knowledge of operations, materials and processes.

The selective utilization of natural resources through construction involves shopwork. The control of nature means changing which again involves the fundamentals of shopwork. It is hard to conceive of shopwork as not entering into the functions of engineering. The designer must thoroughly understand shop, the supervisor can not supervise efficiently without its knowledge, the constructor and the operator use its fundamentals first hand, the adviser can not intelligently advise unless he understands its underlying fundamentals. It is the engineer's duty to formulate an ideal. That is theory. But all that work is waste unless from that idea the engineer can create a reality. The creation of the reality means fabrication, leading back again to a more or less extent to shopwork fundamentals. Since engineering colleges are trying to meet the above situations, to train engineers to perform the above functions and duties, it means that if shopwork is put aside, they have created a gap in the engineer's education and since shop and its fundamentals play such an important part in so many branches of engineering, it behooves the engineering educator, not to operate and cut out shop, but to use corrective measures of less violence and make the shop situation a healthy one, one in which it is performing its particular function to the last point.

This conclusion does not imply that the usual type of present day shop is satisfactory and is fulfilling educational needs.

There are several reasons why summer shop does not prove a substitute. Reasons are; difficulty of student placement, lack of money for proper supervision, lack of supervision, the type of work generally open for summer employment, and the difficulties of supervision and coördination in conjunction with the industries, which naturally are business institutions and not educational. In general, it may be said that only if it is possible to supervise properly

the shop given is it desirable. It appears from the data that the majority of schools without shop favor required shop in industry which would mean that they think there are educational values in shop.

Nothing should replace shopwork, but it should be thoroughly revised and reorganized to be of full educational value for professional engineering education. It must be brought up to the professional level and cease to be a trade training. Real objectives must be put to work.

While very little has been done in the field of semi-technical education, which includes training for chemists, draftsmen, surveyors, foremen, and the like, something should be done, particularly as long as the selection of engineering students is the chance method as it is at present. Reference might be made to Lehigh University's system. The writer believes their arrangement holds great possibilities. Generally in engineering schools the first two years are fundamental years of preparatory work, and the technical work starts at the third year. Therefore in order to make those first two years as valuable as possible to everyone concerned they should be so arranged that in addition to preparing the student for his more advanced technical work, they should give at the same time the most valuable and usable training for those who are eliminated during those years. The ideal would be to carry each student to his best level and send him out into industry successful as far as his education is concerned.

In order to start on any program, it must be known what is trying to be done by the inclusion of each phase of engineering education. The tendency seems to be a lack of knowledge of concrete direction or of having so many paths or objectives that the guide or instructor is lost in the maze. It is the writer's personal belief and experience that when the number of objectives for one course gets beyond three, the situation begins to get to a point where there is no more effective guidance than if there were none. Out of these three, it is still better if one is paramount. Then a definite path and procedure is pointed out. Sometimes other purposes may be worked in incidentally. There is the opportunity to bring in more desirable incidentals by different organization and still travel towards the definite objective.

The paramount purpose of engineering shop appears to be to give a practical knowledge of materials, perhaps with emphasis on the practical. The other two most important objectives become; a knowledge of design, and a knowledge of production and manufacturing. Meeting these objectives means also meeting engineering objectives and functions. All other items should be subordinated to the above three. Skill of hand should be entirely

incidental except in special cases. Those purposes which tend towards formal discipline can be put aside.

Perhaps the training of practical judgment should rank high as a purpose. However as a means of expressing a purpose it is too intangible. Therefore it has not been listed of prime importance. The writer believes, however that as a course is organized in detail that incidental items might be brought up with course details. For example, with each detail put into the course the question might be raised; does this way lead to a real development of practical judgment or does some other way do it better? If the question is satisfactorily answered, then the incidental may be brought in to some advantage.

Other than mechanical engineering students should take shop. If for no other reason than that so many engineering graduates follow some other work than their own studied course, and since industrial work comprises such a large proportion of available positions, the majority will gravitate into positions where knowledge and education received in proper shop courses will be as valuable to them, if not more so, than any course they could have taken.

The fact that other than mechanical engineering students should take shop does not imply that subjects vitally important to the curriculum should be dropped to give shopwork. But since a scheme of guidance is as little developed as it is and many get into courses where they do not belong, and also since many are advocating a more general course embodying fundamentals, the writer believes that shop through electives should be open to all, who may desire to take it.

The writer agrees, in part at least, with some of the men in industry who replied to this study, that shop should be given but it is not so important what shop, as the fundamentals are or should be embodied in the various shops. Therefore where differences have not proved significant, the shop is not included or is elective. The only shop which appears in universal disfavor is the production shop. The reasons for this are undoubtedly the expense and the difficulty in giving such a shop. This type of shop to be effective requires a much higher type and broader vision than the average shop instructor seems to have. However with proper material and organization the features of production can be very aptly illustrated in the various shops where desirable.

The adverse part of the faculty and particularly the student has to be convinced of the value of shop to himself as a graduate engineer. The writer believes that the changes recommended and a proper program by the shops divisions will convince the student of the value of shopwork. He not only has to be convinced but he has to be kept convinced. A good many students lose their faith in

shopwork after they get into the courses as now given. No course performs its full value unless the student is convinced of its value to him.

At present there seems to be quite a lack in connection between the shops and the other work in the curriculum. The writer is inclined to think that in many schools reporting connections the connection is more theoretical than actual and vital. There should be a well defined connection between the shops and the other work in the curriculum.

The shops should in part at least form a transition from phases of chemistry, physics, strength of materials, metallurgy, and so forth, to engineering subjects such as design and the like.

In general the reports stated that objectives were put into use. While it may be considered presumptuous to say so, here again the writer thinks the situation is more theoretical than actual, as personal observation in many cases has verified such a statement. Many instructors seem to have a rather slight conception of what they are driving at other than trying to teach a trade. Some have the added perception of appreciation. While not intending to reflect upon the old time shop instructor who still appears to dominate the shop instruction in engineering colleges, the writer feels that, since they are only expert mechanics, and since many have passed the stage of being progressive, they are, in general, unable to formulate shop course programs putting objectives to real active use.

All shop instructors should be technically trained engineering graduates with two or three years of industrial experience, and if possible good mechanics, but not necessarily journeymen. And naturally he should be able to teach and understand educational problems. The writer feels that if there is any discrimination, it requires a man of higher caliber in shop than in the academic work.

In opening the way to a higher class personnel in general, the salaries and titular rank should be as high and as accessible as in any other division of the engineering college.

Diversity of results in the use of instructional aids indicates a lack of general thought on that side of shop courses. Certainly instructional aids of certain kinds ought to be in broad use. Lack of the use of aids, lack of engineering purposes, lack of organization, lack of an educational consciousness, have all contributed to shop deficiencies. There are a few shop departments however, apparently not lacking universally in the above deficiencies and they seem to be far in advance of the others. These are only a handful. The writer feels that student attitude on shop not being worthwhile has been promoted by the above deficiencies.

The factors given for class size were lack of equipment and lack

of room, yet course organization will partially mitigate for the material lack. Material lack can at least be partially compensated for, but lack of proper personnel on the instructional staff can not be compensated for. A high type of instructor and poor equipment will do decidedly more effective work than a very poor instructor and excellent equipment. In the writer's opinion also, course organization has more to do with class size than any other one factor. It allows for much better instruction, a better proportioning of the instructor's time, more initiative on the part of the students, at the same time it gives much more effective use of the equipment and therefore it allows much larger classes, cutting down the instructional cost.

The opinion of those in industry should carry considerable weight, as it is in industry that the engineering graduate finds himself upon graduation. Since all these men in industry who coöperated in this study are all in positions in which they have a bird's eye view of their college employees, their opinions should be still more valuable. They were decidedly in favor of shop of some kind.

In conclusion, shops should be retained but should be made educationally effective in professional engineering education. The next division on recommendations contains the writer's present best judgment as to how this may be effected.

Recommendations

It perhaps might be mentioned here that a curriculum analysis, following Bobbitt's or Charter's suggestions, would start as a form of analysis of the life situations in professional engineering in practice. To make the analysis complete there should be a study of each branch of engineering as civil, mechanical, and so forth. From this study the aims could be formulated and material content determined. Such a study would naturally give the shop material for the various curricula as accurately as it could be determined. The study would also, perhaps, help determine the amount of shop. Since the time and cost of such a method would be prohibitive, a different method has been used. This method, while perhaps not as basically sound as the method above, still should give some usable results. While the method used is not the ideal, it is practical.

In making recommendations for shop improvements the following considerations will be taken up: first, the general plans that may be followed; second, those curriculum courses in which shop is recommended; and third, the shop courses that are recommended for the various curricula in which shop might be given. The selections of the first are based upon the writer's understanding

of the previously mentioned objectives. The selections for the last two are based upon the statistical returns.

There are three plans that may be adopted, and any one of these three, it seems, meets both educational and engineering purposes. These three methods are exclusive of various systems of coöperative education. These three plans are as follows:

1. Required high school shop, followed by professional shop laboratories in the professional school.
2. Required summer shop, either in industry or the school shops, followed by professional engineering shop.
3. A regular production shop as a laboratory.

While it is not the purpose of this article to go into a complete program, nor to go into the detailed application for what is considered true engineering shops, yet a few points may be mentioned to explain the above three solutions.

Shop as now generally given is a high school subject. Furthermore, the writer has seen many high school shops that are doing a much better job in teaching shop than the average engineering shop, as now constituted. And surprising as it may seem, the instructors seem to be of a higher caliber in general, particularly in the so called technical high schools. This has been brought about by the raising of the standards for high school instructors and also through the Smith-Hughes work. With this situation, the place for regular shopwork of the trade type is in the high school and not in the engineering school. Shop is accepted for college entrance credit now at many of our best schools, although it is not required. Shop should be set up as one of the entrance requirements. These requirements should help the development of school shops in those schools in which shop is not now given or improve those already in existence. Other benefits to the high school curriculum and social atmosphere could be mentioned here but that is another subject.

To take care of those students who are unfavorably situated in regard to secondary shop, the second plan is recommended. If a student is able to get the right kind of shop training during the summer, this should be substituted for the requirement. This shop, however, should be of the right kind and only accepted upon adequate proof that it is the right kind. Requirements should be set up so that the student would know ahead of time just what type of shopwork would be acceptable. Since by far the majority of the professional schools have shops of some sort at the present time, they should be retained as they are until such time as the high school programs call for shops. If they are following educational development, the suggestion of required shop for engineering should not set up any hardship. Such development should be encouraged

by the engineering schools. When the development becomes practical there would be no further reason for the engineering school to have shops as now constituted. It might be added that secondary shop helps meet the seven cardinal principles of secondary education as much or more than most subjects now in the curriculum. In order not to crowd the program in engineering, the shop as retained, to be given to those unable to get the shop in any other way, should be concentrated in the summer term. In some cities the student is able to take shop in the summer in the local high schools.

The engineering shop laboratories would be given during the year as a part of professional engineering education. These laboratories would be quite different from the traditional type. The development of a proper lecture and demonstration laboratory, which would constitute the shop laboratory would be the center of the course. The writer has seen such laboratories in conjunction with the traditional shop, which if developed would certainly fulfill the needs of professional engineering shop. At present this auxiliary room occupies a rather inferior position in the shop plan. The summer shop or the high school shop would give the necessary preparation to the student so that he might profit to the best advantage from the professional course just as high school mathematics and science furnish or are supposed to furnish a background for other work in the curriculum. This type of course would not necessitate the large investment in machines, tools, and floor space. Also the size of class could be much larger. While more money might still be spent over a standard academic course, yet the shop cost should be reduced considerably. The amount of machinery required, the space, the operating expense would be much less. Money formerly spent on a large number of machines could be concentrated on single up-to-date machines since only one machine of a representative type would be required. No attempt should be made to cover special machinery except as an important part of class room instruction. A study of a group of industries might be made to determine what type of machines are more or less universally used and only universal machine types should be considered as laboratory equipment. Also having only single machines, there should be the better opportunity of disposing of these machines and replacing them when necessary to keep them up-to-date. Every industrial concern does not have so called up-to-date equipment. If it is cheaper to keep the old, the old will be kept. The writer has seen plenty of old equipment in use in actual plants, and these plants were progressive if profits under modern competition means progressiveness. However, the producer that is awake keeps his finger on costs and as soon as the facts indicate a new method that is

much cheaper, that method comes into use. Many concerns have become bankrupt because of the inadvisable buying of new equipment. The same fundamental considerations hold for the school laboratories. The criterion is different in that in industry it is profits and in the schools it is educational values, as partly determined by industrial development.

The aids in a course of the kind mentioned above would be: texts, notes, lectures, demonstrations (by instructor and students), problems, moving pictures, slides, supplementary material, group conferences, and tests. One large lecture and demonstration room for one hour a day for three days a week or whatever time is advisable for particular courses, with groups of any desired size, is all that is necessary with the right caliber of instructor and course organization based upon the objectives, for giving a real professional engineering shop laboratory course which would be far more valuable educationally to the engineering student, would require less equipment, and eliminate equipment that may be good but idle most of the time. Idle equipment is useless and wasteful.

While the course organization, aids, materials, and the like are important because they may determine success or failure, it is not the purpose here to give all those details of application, many of which might happen to differ somewhat in different situations.

The three preceding paragraphs merely suggest what is included in the engineering shop laboratories. It is an engineering course and not a trades or a modified trades course. It must be remembered that the regular shop course provides a background for the engineering course.

In the small engineering school a general laboratory for all shops might be included in one. In the large school each shop might have a special laboratory. The above types would help take care of the number of students, help keep expenses to a mimimum, and help use all equipment to the best advantage.

The third plan of the three would be the best one of the three were it not so difficult to operate it. Some state laws would prohibit a true production shop. The writer feels that while some schools have shops classified as production shops yet it is impossible to have such a shop unless it is made a real business. There is no reason why a real commercial shop cannot be built up and maintained providing there is a high enough caliber of man to develop such a shop. If we are to have a real production shop there must be outside orders large enough or enough orders of small size to operate the shop. Where the commercial shop is prohibited, plan 1 or 2 is recommended. In building up a commercial shop, the purpose of the shop would not necessarily have to be self-supporting, however if the business could be obtained to make it so, it should be.

The writer has thought of one market that might be tapped in some states. From the elementary school through the state university is the complete range of public education. A market could be built up for furnishing various requirements to the schools inside the state at cost. This would mean cheaper buying for the schools, at the same time providing the best type of laboratory. The writer even sees no serious objection to paying students on an incentive basis for what productive work they actually did. This type of shop organization would supply a real life situation. A type of program could be worked out whereby the lower classmen would furnish the lower types of experience and work, all of which are foundational. The functions of management could be delegated to the upper classmen who had shown their abilities. They already run large newspapers and in some places actually supply the town in which the school is located. They do other things of equal worth. Therefore while the above shop would be a new application, the basic idea would not be new. It would bring in many other engineering functions which would be operating under life situations. The medical men have their hospitals; why not give the engineers the same type of advantage. The development of such a plant would bring in many things, which, the engineering student at present can only read about or hear a lecture on and then forget. Power problems, power transmission problems, design problems, manufacturing problems of all kinds, even marketing and distribution problems would arise. It would be a real laboratory. While the general comment on the above solution will be that it is impossible, it is only so because it is looked at on the basis of the past and not the future. The development of such a laboratory, again first of all comes back to the capabilities of the individual doing the job and the coöperation he is given. While such a laboratory would require time in building it up, yet when the job was done, that school could boast of having the best engineering laboratory in the United States. There are many ways and means of working the above plan and getting it into operation. While it offers by far the most difficulties, it also offers the most opportunities. This laboratory could also be used as a research and experimental laboratory by those students and others who might be particularly interested in the problems offered.

Again it should be stated that the courses should be organized around the three objectives as given under conclusions.

The following list gives those curriculum courses in which shop is recommended. This list is not based upon personal judgment but upon statistical results. Significant differences are used in choosing shop courses. The assumption is made that the consensus of opinions obtained constitutes a valid basis for curriculum con-

struction. Since unless plan 3 is adopted there can be no production shop, it is omitted. Production study comes in as one of the objectives in the previous mentioned laboratories. It is believed that production can be studied as well in the new type, and perhaps better than with the standard shops. In no case was the difference significantly in favor of a production shop.

The following tabulation gives the curricula with their shop courses as recommended from the statistical study. (As taken from the consolidated table for the principal curricula.)

Engineering	Pattern	Foundry	Forge	Mach.	Heat Treat.	Weld
Mechanical	R	R	R	R	R	R
Electrical	R	R	R	R	E	R
Civil	—	—	—	—	—	—
Chemical	—	—	—	E	—	—
Mining	—	—	E	E	—	—
Industrial	R	R	R	R	R	R
Architectural	—	—	-	—	—	—

The following is from department head data only including all department heads in their respective departments.

Engineering	Pattern	Foundry	Forge	Mach.	Heat Treat.	Weld
Mechanical	R	R	R	R	R	R
Electrical	E	E	E	R	E	R
Civil	—	—	—	—	—	—
Chemical	—	E	—	R	—	—
Mining	E	E	E	E	E	E
Industrial	R	R	R	R	R	R
Architectural	—	—	—	—	—	—

The following is taken from those department heads only who were in favor of shop.

Engineering	Pattern	Foundry	Forge	Mach.	Heat Treat.	Weld
Mechanical	R	R	R	R	R	R
Electrical	E	E	E	R	E	R
Civil	E	*E*	*E*	E	E	*E*
Chemical	E	E	E	R	E	E
Mining	E	*E*	*E*	*E*	E	E
Industrial	R	R	R	R	R	R

R means required.
E means elective.
—Means no shop either required or elective.
R or *E* means appeared of most importance.

The class sizes that were given as the best for the present type of shop do not apply in the new type of recommended shop. No recommendations are made in regard to the size other than to comment that the class size would be determined by the same factors that determine any other academic class size.

For the hours per week for one semester that each course should have, also no definite recommendations are made. Table 1 gives the average hours per week for one semester for all courses. Since there is a wide variation in the number of hours required at the various schools, the number of hours is indeterminate except for the average and since no more reliable figure is at hand, the averages have been given. This again applies to the old type of shop. It appears from a personal study of the time required by the new type that it will be close to that required at present but probably with a different distribution over the week. The course organization and other such features will have an influence on the time required. Therefore it becomes largely a matter of application.

In closing, the writer feels that the problem has not been completely solved. But he hopes that some avenues of approach have been created, from which a better and sounder shop policy may be developed, and this in turn will lead to the development of the best possible type of professional engineering shop laboratories, laboratories that are *engineering* laboratories and not just trade shops which they seem to be in practice and operation.

COMPREHENSIVE EXAMINATIONS IN THE DEPARTMENT OF ELECTRICAL ENGINEERING, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The comprehensive examination as conceived by the Department has four distinctive features: (1) the examination is one covering electrical engineering as a professional field rather than one dealing principally with the details of individual subjects or comprehensively with any one subject, (2) the examination consists therefore primarily of a number of questions (perhaps ten for any individual student) of a semiproject nature each more or less comprehensive in itself, that is, in one problem may be involved the application of principles of mechanics, thermodynamics, hydraulics or economics, as well as principles of electricity and magnetism, interwoven in the fashion naturally found in practice rather than artificially isolated, (3) adequate time (the major portion of two weeks) is allowed for preparing the answers so that they may be the result of reflection and mature thought rather than of hasty and incomplete analysis, and (4) an oral session is held subsequent to the reading of the papers, at which time the examiners may question the students further as a consequence of the written answers given, following which general discussion relating to the examination problems and to the summing-up of the purposes, utility, and success of the examination procedure is in order.

The examination is set by a committee consisting of three members invited from industry and other engineering schools and two members selected from the Department staff. It covers all of the professional work of the junior and senior years together with its scientific foundation. It is designed to test the understanding of principles and the ability to carry the reasoning therefrom through to a finish, rather than the ability to solve problems by analogy to familiar classroom or textbook forms. Emphasis is therefore placed upon analysis and judgment rather than upon memory. Reference is permitted to texts, handbooks, periodicals or any other sources of information desired, though each student's work must, of course, be individual.

Though the examination is comprehensive in scope, it should not be thought of as general or superficial rather than exact and searching in nature. The problems appearing in it require a deeper understanding of basic principles and more exacting analysis than those in the usual term examinations.

The use of comprehensive examinations in the Department has

thus far been limited to the students of the Senior Honors Group, which averages about eighteen men per year and varies from class to class from about ten to twenty-five.

The Honors Groups are formed at the end of the sophomore year for those students having appropriate scholastic records and personal characteristics, and are carried through the junior and senior years. With consent of the Faculty, the students in these groups are free from the routine of class attendance and solution of repetitious practice problems in all of their subjects and are encouraged to work upon problems of an investigative nature in the laboratories rather than to adhere to conventional weekly assignments. The time freed by this arrangement, which is very considerable, and the more effective use of time which it allows, provide opportunity for reading and reflection related to the subjects of the curriculum, for the purpose of deepening the understanding of and perceiving the interrelationships of the subjects of the curriculum; and also for a certain amount of general reading which may unfold a view of the importance of engineering education and practice in the modern social order. This encouragement of individual work by lessening the demands of conventional hours, is a primary object of the honors group plan. As an aid to carrying this out, certain staff members are designated as conferees or counselors for honors group students. However, one of the important factors in accomplishing this correlation of subject matter so that the field of electrical engineering is viewed as a whole, is the comprehensive examination, the importance of which has been increased each year since its initial trial for the class of 1928. While the comprehensive examination serves also as a measure of achievement, its chief purpose is to exert an influence upon the habits of study of the students during the two-year period of honors group work.

In general, honors group students are held responsible also for the usual written quizzes and term examinations,* except in the second term of the fourth year. In that term they are released from all final examinations and intermediate quizzes in favor of and to provide time for an adequate comprehensive examination.

Though the comprehensive examination has been employed only for students of the Honors Groups, the plan is not carried on as an isolated feature of the Department's processes. It is carried on in association with and gains considerable support from the practice of grouping the students into small teaching sections, in accordance with their observed mental speeds and capacities, so that each

* As a special test case, one well qualified junior has been granted freedom from examinations and intermediate quizzes for most of the two years of honors study, at the end of which time he will be given a comprehensive examination especially designed for him.

student finds himself in a group of relative mental homogeneity in which the mode of instruction is designed to meet his needs. The arrangement is flexible, however, for a student may be transferred from one section to another or may be given the opportunity of becoming an honors group student, in accordance with his progress and performance. Hence the comprehensive examination is a potential influence upon every scholarly and ambitious student in the Department.

The examiners chosen for the Honors Group of the Class of 1931 are Mr. O. B. Blackwell, Transmission Development Engineer, American Telephone and Telegraph Company; Mr. F. M. Carhart, member of the firm of Jackson and Moreland, Consulting Engineers; Professor F. C. Stockwell, Anson Wood Burchard Professor of Electrical Engineering at the Stevens Institute of Technology, and Professors Dahl and Fay of the Department staff.

The results of the comprehensive examination as a measure of achievement have been very good. Though no formal honors are awarded to students whose comprehensive examinations are of high quality, most of the papers have been very satisfactory, and none could be considered failures. While the present status of the comprehensive examination is of too recent date to permit conclusions to be drawn relating to its influence upon habits of study, the situation is very encouraging. The first two years in which comprehensive examinations were tried, the honors group students took them voluntarily in addition to their other examinations, as a matter of interest in testing themselves, and to coöperate with the Department for the purpose of experiment. The students do not, in general, fear the comprehensive examination, but (on the contrary) favor it and its associated intent.

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

Summary of report of the Summer Session Committee.

Examinations and Tests of Achievement

The committee concluded its report with the following recommendations:

"1. That the Drawing Division of the S. P. E. E. be requested to make a careful survey of the present status of Placement and Achievement tests among our teachers of freshmen engineers.

"2. That, through the Drawing Division, an attempt be made to conduct a co-operative testing program between small groups of colleges whose methods and course content are somewhat similar."

Descriptive Geometry Problem

"There is one problem over which I spent some time before solving and would like to know the solution of others for the same type problem; that is, having given three of the four traces of two planes and the angle between the planes, locate the fourth trace. I would suggest the following set up. *HS* 45° and *VS* 30° with the ground line, *VT* 70° with the ground line, crossing *VS* at 100°, and the angle between the planes *S* and *T* of 75°. What would be the method of locating the two possible settings of *HT*? "

Submitted by Professor F. H. Cherry,
University of California.

Questionnaires

Within the last month, I have filled out two questionnaires on subjects of interest to teachers of engineering drawing. Last year I am sure that I answered as many more. I do not mind the labor of answering, but I rebel that a compilation of results—of vital interest to teachers in this field—is seldom forthcoming. The cure, or the remedy, for this waste? I suggest:

Let the Division of Engineering Drawing agree to authorize questionnaires, and the members bind themselves to answer no questionnaires not licensed. To be licensed, a questionnaire (*a*) must not cover a field of inquiry already investigated; (*b*) must be of value and related to the field of engineering drawing; (*c*) must be filed for reference with the secretary when completed.

This is but the germ of an idea. Let us hope it may germinate into a plan which will encourage inquiry and make the results of it available to all. Editor.

* * * * * * * * * * * *

". . . In Engineering practice it is no longer sufficient that a structure or a machine satisfy the requirements of technical formulae. This, of course, will always be prerequisite. But the world today demands that Engineering achievement shall catch and express in permanent form the emotional inspiration that lies behind great planning and great doing."

". . . A group of students, filled with the desire to build magnificiently, to create splendidly, filled with the surging desire of youth to go forth and conquer, not dragons or giants or tyrants, but the last challenges of recalcitrant nature, or to discover unknown principles which will increase human happiness, will not be satisfied with a course content which, though perfectly co-ordinated, yet does not give Engineering Education an opportunity to display the art of inspirational development."

". . . It is essential that, somewhere in our set-up of drawing work, some source of continued interest be provided for the teacher which will match the native enthusiasm of the student. It must be obvious that to restrain the efforts of a good drawing teacher to the mere ***finger twitching exercises***, while others have the privilege of making the application to the advanced drawing, can only be depressing to him."

Professor Harry M. McCully,
Carnegie Institute of Technology.

CO-OPERATIVE ENGINEERING EDUCATION

W. H. TIMBIE, *Editor*

Twenty-five years is a long forward look, but a short backward look. If anybody had asked me twenty-five years ago how long it would take to obtain a highly efficient co-operative scheme, I would have answered that it would take about fifteen years. But now, after twenty-five years of work, I can see a great many things that have not been brought up to the point of satisfactory fulfillment. This may be due to the fact that I am twenty-five years older than I was, and that my point of view has necessarily changed somewhat.

I do not mean, of course, that in its major phases the co-operative system has not worked. It has. A dispassionate appraisal of it would warrant me in saying that it is so much better than the old system that I am convinced of its worthiness. In its major aspects it has worked out according to schedule. It has met four depressions and has weathered them all. It has been found to be workable in all of the phases of Engineering, in Commerce, in the Applied Arts, in Medicine, in Political Science, and in non-professional fields in connection with Liberal Arts courses. In other words, it is a workable scheme mechanically, and it trains most efficiently for definite professional, and in some cases for non-professional service. For example, in the one medical college which has tried it out, for about six years, the examination of students disclosed that professionally they were considerably ahead of students in the usual non-co-operative courses. This has been found to be true also to a very marked degree in Engineering, Commerce and the Applied Arts, so that from the point of view of making a more efficient professional man, I think there can be no question of its success as compared to the usual non-co-operative methods.

When I say that there are several phases in which it may not have worked to the point which I had expected, I do not mean that it has not worked as well as the non-co-operative courses. Even in the fields where I am in doubt as to its having reached the mark I had anticipated, it has surpassed the non-co-operative courses.

It is hard to define the non-professional aspects. Frankly, I had in mind the idea that the leaven of college life and college ideals would permeate professional affairs more through the co-operative system than through the non-co-operative system. My honest conviction is that the co-operative course has served this purpose, but the one disappointment I have is that it has not served to so high a degree as I had anticipated.

Of course, this is a sheer guess on my part, because an appraisal

of values of this sort is not at all possible except through guessing and through observation of a very superficial type. There are no bases for absolute mathematical statistics in such an appraisal, for it is just a matter of opinion.

Obviously, any professional school has two major functions: first, to train professional men to be good and efficient professional men; and second, to implant in them more deeply the idea of a more unselfish and more altruistic service. For example, it ought to be the purpose of the university, in its professional departments, to train better lawyers, better doctors, better engineers, and at the same time give them, to a higher degree, the spirit of service necessary to enable them to enter positions of influence, and to steer the evolution of affairs in a safe direction. They should not only be proficient professionally, but proficient from the point of view of directors of human thought and action, to the end that life will be better for everybody, and the thing we call civilization a less rickety thing.

The appraisal on professional efficiency is easy to make, and shows that the co-operative system does train much more efficiently in this one item of the professional man's activities. The appraisal as to his influence on the development of sound systems in those items which make up the less tangible, more important phases of life, is very difficult to make. As I said before, my guess is that the co-operative system does add to the intangibles as well as to the tangibles, more than the non-co-operative system does, but I am not sure that we have done all we can to bring it up to the point which was in my mind twenty-five years ago.

This seems to me to be the next big task. Men in important professional positions in law, medicine, engineering and commerce are at key points of leadership. It is not enough to be skilled professionally. It is a lot, but not enough. While we have gone a fair distance in developing in co-operative students the vision necessary to leadership, and further, in my opinion, than the non-co-operative system has gone, I am convinced that having solved the question of professional efficiency, our big problem is now to work out methods by which the problem of the intangibles of leadership outside of professional skill can be solved.

This does not mean more courses in History, Economics, Literature, and so on. It means the introduction of something which the colleges have lost generally, but which they had in former days. It is not a matter of size of colleges; it is a matter of spirit.

I think the problem is fairly before us, and to me there seem to be certain definite methods of a non-pedagogical type which perhaps would aid in its solution. It is to these that we must now give our major thought, and they ought to constitute our points of attack in the years ahead of us.

HERMAN SCHNEIDER, *President,*
University of Cincinnati

ENGINEERING SCHOOLS CONFER ON TEACHING MANAGEMENT OF MEN

A conference on preparing engineers and business school students to deal with and manage men and industrial relations, was held on March 29, 1931, at the home of Mr. S. A. Lewisohn in New York. It was called in order to provide opportunity for discussion of methods and interchange of experience among the men engaged in teaching courses in this pioneer field. Representatives from over twenty business and engineering schools where such courses have been instituted or are in contemplation, together with business executives and others especially experienced in this field, attended.

The conference was the immediate consequence of the report of the Committee on Industrial Relations of the S. P. E. E., presented at Montreal last June, which in discussing the question, "Can The Engineering Student Be Taught to Manage Men?," brought out the importance of courses which will cause the student to become more sensitive to the human factors in his experience and give him a method of approach to problems of human relations. The conference was also an outgrowth of two previous conferences at Mr. Lewisohn's house, called at the instance of industrial leaders in order to put before the deans of engineering schools the importance of preparing engineering students to handle the human as well as the technical aspects of their work.

One of the striking characteristics of the recent conference was the advance made since the earlier conferences. Two years ago, the conference at Mr. Lewisohn's house confined itself almost wholly to discussing the desirability, and even the practicability, of such teaching. At the recent conference, there was such complete assent on this point that the conference took it for granted and settled down immediately to discuss objectives, subject matter and methods.

"To prepare students *to learn from experience* to deal with and manage men and industrial relations, not to produce managers ready-made," was concurred in as the underlying objective of all such courses, in a discussion initiated by Elliott Dunlap Smith, Professor of Industrial Engineering at Yale, and Joseph H. Willets, Professor of Industry at the Wharton School, University of Pennsylvania. The particular aims of such teaching should therefore be (1) to give students an orderly background in regard to industrial relations which will enable them to see their problems in perspective and be the basis of a sound philosophy; (2) to make them more aware

of and sensitive to the human factors in their work; and (3) to develop in them habits of objective, penetrating analysis of their problems of human contacts and of industrial relations.

In discussing subject matter, Joseph W. Roe, Professor of Industrial Engineering at New York University, and Ordway Tead, Lecturer in the School of Business at Columbia University, emphasized two types of material: on the one hand material relating to the history, scope, organization, practices and social significance of industrial relations; and on the other hand material relating to individual human contacts and management. Both added that an understanding of human relations would be aided by vigorous study of the psychology of everyday behavior, taught, not as a dry dissected thing, but as principles underlying the action of living men and groups.

This emphasis on reality was carried forward in the discussion of method led by Professor Herman Feldman of the Tuck School at Dartmouth, Professor John R. Bangs of Cornell, Professor John Younger of Ohio State, and Professor E. H. Schell of Mass. Institute of Technology. While they stressed the importance of flexibility in method, and its subordination to the requirements of the particular course and situation, they also indicated the importance of employing methods that as far as possible expose students to problems, cases or experience, and cause them to think for themselves in regard thereto.

The conference, which was presided over by Mr. C. E. Davies, Assistant Secretary of the A. S. M. E., appointed a committee to arrange for a similar conference next year. The members of the conference were the guests at dinner of Mr. Lewisohn, who presided at the dinner and introduced as speakers Mr. Gano Dunn, President of the J. G. White Engineering Corporation, and Mr. F. W. Willard, Assistant Works Manager of the Western Electric Company. Both speakers stressed the importance of right social thinking on the part of engineering graduates.

The outstanding features of the conference were the unqualified acceptance of the desirability and possibility of preparing engineering and business students for the human side of their work, the emphasis upon focussing such teaching upon preparing students to learn from later experience, the double subject matter of human contacts and of industrial relations, and the importance of methods that, as well as retention of information and development of understanding, bring about individual thought and action on the part of the student.

SECTIONS AND BRANCHES

At the Spring Meeting, Ohio Section, held at Antioch College, April 25, the following officers were elected for the year 1931–32:

Chairman: Walter A. Gilmour, Municipal University of Akron.
Vice-Chairmen: T. C. Lloyd, Antioch College, Samuel B. Folk, The Ohio State University.
Secretary: Sada A. Harbarger, The Ohio State University.

Minutes of the Organization Meeting of the Texas Section.—At the invitation of Dean F. C. Bolton, seventy-five teachers of engineering or related subjects met at College Station on the evening of April 3 to form a Texas Section of S. P. E. E.

At the banquet which was complimentary to the visiting delegates, Dr. F. E. Giesecke presided as toast master and introduced President T. O. Walton who welcomed the visitors to A. & M. College. Dean Bolton explained the purposes of the gathering and outlined the advantages to be obtained by the formation of a Texas Section of S. P. E. E., and also the proper method of procedure. Representatives from other institutions were called upon for short talks and all expressed a desire to see such an organization formed.

At the business session which followed the banquet, Dr. F. E. Giesecke was elected temporary chairman of the meeting. It was moved that we proceed to form a permanent organization. Carried. Moved that the chairman appoint a committee of three to draft a constitution. Carried. Professor E. C. H. Bantel, Dean F. C. Bolton, and Dean E. H. Flath were appointed. Their report was unanimously adopted as the constitution of the permanent organization and is included as part of these minutes. The following permanent officers were then elected:

President—Dr. F. E. Giesecke, Texas A. & M. College.
Vice-President—Dean W. J. Hiller, Texas Technological College.
Secretary-Treasurer—Professor J. A. Correll, University of Texas.
Executive Committee:

Dean F. C. Bolton, Texas A. & M. College,
Professor L. B. Ryon, Rice Institute,
Professor E. C. H. Bantel, University of Texas,
Professor C. L. Svensen, Texas Technological College,
Professor F. M. Smith, North Texas Agricultural College, Arlington, Texas

Dean E. M. Flath, Southern Methodist University,
Professor H. C. Doremus, Jno. Tarleton Agri. College,
Dean R. L. Peuriqoy, College of Arts & Industries, Kingsville,
Professor J. W. Kidd, School of Mines, El Paso.

After some discussion the selection of the time and place for the annual meeting was left to the executive committee. The meeting then adjourned.

On Saturday morning, April 4, 1931, the following program was presented:

TECHNICAL MEETING

Chairman—Professor J. J. Richey, Texas A. & M. College

Rainfall Characteristics of South Texas. Professor W. E. White, Rice Institute.

Discussion.

Objectives of Surveying Courses. Professor O. V. Adams, Texas Technological College.

Discussion.

Recess.

The Development of our Freshman Problem's Course. Professor Charles Crawford, Texas A. & M. College.

Discussion.

Open floor discussion of the aims and objectives that may be considered common to nearly all courses in engineering.

Adjournment.

Those attending the organization meeting were as follows:

Name	*Institution*	*Department*
L. E. Grinter	A. & M.	Civil Engineering
Edgar W. Dunn	"	Drawing
C. W. Burchard	"	Chemistry
H. C. Spencer	"	Drawing
C. C. Palmer	"	Electrical
S. J. Boller	Texas Tech.	Drawing
Elmer Hall	" "	Mechanical Engineering
O. V. Adams	" "	Civil Engineering
H. T. Godeke	" "	Mechanical Engineering
O. C. Perryman	" "	Engineering Drawing
O. D. Brandt	" "	Textile Engineering
W. E. Long	A. & M.	Mechanical Eng.
W. E. Street	Texas Tech.	Engineering Drawing
F. E. Giesecke	A. & M.	Engineering Research
R. D. Campbell	S. M. U	Mechanical Eng.
Sophus Thompson	"	Civil Eng.
Bob Slaymaker	"	Mechanical Engineering
R. S. Landon	"	Mechanics
M. K. Thornton, Jr	A. & M.	Chemical Eng.
Joseph W. Ramsay	Texas Uni.	Electrical Eng.

M. C. Hughes	A. & M.	Electrical Eng.
H. F. Huffman	S. M. U.	Electrical Eng.
J. A. Correll	Texas Uni	Electrical Eng.
B. H. Gafford	" "	Electrical Eng.
E. H. Flath	S. M. U.	Dean of Eng.
Geo. Summey, Jr	A. & M.	English
E. W. Steel	"	Sanitary Engineering
A. E. Finlay	"	Mathematics
H. R. Brayton	"	Chemistry
C. C. Hedges	"	Chemistry
A. V. Brewer	"	Mechanical Engineering
H. Dillingham	"	Electrical Eng.
D. W. Fleming	"	Mechanical Eng.
Robert L. Mills	"	Pet. Production Eng.
C. E. McCarter	Texas Uni.	" " "
W. W. McCarter	A. & M.	Mechanical Eng.
E. W. Markle	"	Electrical Eng.
R. P. Ward	"	" "
A. H. Kerns	"	" "
J. B. Bagley	"	Textile Engineering
C. H. Winkler	"	Vocational Teaching
J. M. Kuehne	Texas University	Physics
B. E. Short	" "	Mechanical Eng.
J. H. Pound	Rice Institute	" "
J. S. Waters	" "	Electrical Eng.
John A. Focht	Texas Uni.	Civil Engineering
J. J. Richey	A. & M.	" "
E. C. H. Bantel	Texas Uni.	" "
J. T. L. McNew	A. & M.	" "
H. C. Doremus	John Tarleton	Engineering
N. F. Rode	A. & M.	Electrical Eng.
Phil. M. Ferguson	Texas Uni.	Structural (Civ. E.)
L. B. Ryon	Rice Institute	Civil Engineering
L. Vernon Uhrig	" "	Civil Engineering
R. R. Crookston	" "	Mechanical Eng.
B. P. Reinsch	S. M. U.	Mathematics
W. E. Hollingsworth	North Texas Ag. Col.	Electrical Eng.
S. A. Lynch	" " " "	Mathematics
W. E. White	Rice Institute	Civil Engineering
T. A. Munson	A. & M.	Civil Engineering
Geo. L. Dickey	N. T. A. C.	Sociology
H. D. McMurtray	"	Physics
F. B. Plummer	Texas University	Petroleum Engineering
R. B. Newcome Jr	" "	" "
F. C. Bolton	Texas A. & M.	Dean of Engineering
J. M. Miller	Rice Institute	Engineering Drawing
T. O. Walton	A. & M.	Adm.
O. W. Silvey	A. & M.	Physics
J. R. Jenness	S. M. U.	Physics
Banks McLaurin	Texas University	Civil Engineering
A. Mitchell	A. & M.	Eng. Drawing
C. E. Rowe	Texas University	Eng. Drawing
M. C. Stone	N. T. A. C.	Head, Dept. Engr.
C. M. Crawford	A. & M.	Mechanical Eng.
Frank Smith	N. T. A. C.	Engineering Dept.

Constitution of the Texas Section of the Society for the Promotion of Engineering Education

Section 1. Name.

The name of this organization shall be the Texas Section of the Society for the Promotion of Engineering Education.

Section 2. Objects.

The objects of the section shall be the promotion of the highest ideals in the conduct of engineering education with respect to administration, curriculum, and teaching work and the maintenance of a high professional standard among its members.

Section 3. Membership.

Membership in the section shall be open to all members of the Society for the Promotion of Engineering Education residing in the State of Texas.

Section 4. Dues.

The annual dues shall be fifty cents.

Section 5. Officers.

The officers shall consist of a president, vice-president, and a secretary-treasurer.

Section 6. Executive Committee.

There shall be an executive committee consisting of the officers and of one member from each of the colleges in the State which maintains a course in engineering. The President of the Section shall be chairman of the Executive Committee.

Section 7. Annual Meeting.

The Executive Committee shall arrange for an annual meeting and present a program for it. These meetings shall be open to all persons interested in engineering education.

Section 8. Election.

The officers and the members of the Executive Committee shall be elected annually at the annual meeting. They shall take office at the close of the annual meeting at which they were elected.

Section 9. Amendments.

This Constitution may be amended by a two-thirds vote of those present at any regular meeting of the section.

AMERICAN ASSOCIATION OF PHYSICS TEACHERS

The first regular meeting of the **American Association of Physics Teachers** was held at the Bureau of Standards in Washington on Thursday, April 30. The meeting was addressed by Dr. Albert W. Hull, Assistant Director of Research at the General Electric Company, on the subject, "Qualifications of a Research Physicist." The discussion was led by President Karl T. Compton of Massachusetts Institute of Technology. The attendance was about 600.

A dinner and business meeting were held in the evening at which there was general discussion of the plans of the organization. The first annual meeting will be held in New Orleans in connection with the meetings of the A. A. A. S., probably on December 31. The programs for this meeting are being arranged by the Executive Committee. Application has been made for affiliation with Section B of the A. A. A. S.

The Association, which was organized at the Cleveland meeting, now numbers 400 members. The campaign for increase of membership is continuing. Applications received prior to June 1 will result in enrollment of the applicant as a charter member. The secretary of the Association is Professor William S. Webb, University of Kentucky, Lexington, Ky.

COLLEGE NOTES

Massachusetts Institute of Technology.—A gift of $170,000 from the Rockefeller Foundation has been announced to be used for research in physics, chemistry, geology and biology, at the Massachusetts Institute of Technology. The fund, which is to be distributed over a period of six years, is intended to supplement the comprehensive plans of Technology for extension of its work in fundamental research, and to demonstrate the importance of investigations in basic sciences.

On May 2nd, in the afternoon and evening, more than 25,000 visitors attended the Institute's ninth annual "Open House." The affair was planned and carried out by the Combined Professional Societies—a student organization. Laboratories and research projects were shown, with students carrying on the regular work. A feature of the occasion was an exhibit in honor of Michael Faraday, showing working models of the apparatus which he used in his electro-magnetic experiments a century ago.

Yale University.—Mr. R. E. Doherty, Consulting Engineer of the General Electric Company, has been appointed Professor of Electrical Engineering in the Sheffield Scientific School of Yale University. Professor Scott will continue as Chairman of the Department during the coming year when he will have reached the retiring age and Professor Doherty will then become the head of the Department.

NEW MEMBERS

FILIPETTI, GEORGE, Professor of Economics, University of Minnesota, Minneapolis, Minn. Frederic Bass, O. M. Leland.

GARCELON, WARREN R., Teacher of Applied Mathematics and Mechanical Drawing, Vallejo Senior High School, Vallejo, Calif. F. L. Bishop, Nell McKenry.

HANNAFORD, EARLE S., Supervisor of Education and Training, American T. & T. Co., Atlanta, Ga. G. C. Anthony, Kendall Weisiger.

HOGAN, MERVIN B., Lecturer in Mechanical Engineering, University of Utah, Box 28, Salt Lake City. R. B. Ketchum, A. L. Taylor.

HOWARD, ALAN, In charge of Educational Work, Advanced Courses in Engineering, General Electric Company, Schenectady, N. Y. Philip L. Alger, M. M. Boring.

KARELITZ, GEORGE B., Associate Professor of Mechanical Engineering, Columbia University, New York City. F. L. Eidmann, W. A. Shoudy.

MANTELL, CHARLES L., Instructor in Chemical Technology, Pratt Institute, Brooklyn N. Y. S. S. Edmands, Allen Rogers.

MCMASTER, ALLEN S., Instructor in Engineering Mathematics, University of Colorado, Boulder, Colo. C. A. Hutchinson, W. K. Nelson.

SLAYMAKER, ROBERT R., Assistant Professor of Mechanical Engineering, Southern Methodist University, Dallas, Texas. R. D. Campbell, E. H. Flath.

TOPPING, ALANSON N., Professor of Electrical Engineering, Purdue University, Lafayette, Ind. C. F. Harding, D. D. Ewing.

WATERS, JAMES S., Instructor in Electrical Engineering, Rice Institute, Houston, Texas. H. K. Humphrey, J. M. Miller.

WILSON, FRANCIS W., President, Wilson Engineering Corp., College House Offices, Harvard Square, Cambridge, Mass. F. L. Bishop, Nell McKenry.

196 new members, 1930–31.

NECROLOGY

CLAUDE IRWIN PALMER

Claude Irwin Palmer, dean of students and head of the department of mathematics at Armour Institute of Technology, died suddenly April 9, 1931.

Dean Palmer was born May 31, 1871, near Battle Creek, Michigan, and his early boyhood was spent on a farm near Lake View, Montcalm County, Michigan. From the age of thirteen he earned his own living and financed his own education. After graduation from high school he taught in district schools, then took the Normal course at the Ferris Institute at Big Rapids, taught in public schools for nine years, and eventually entered the University of Michigan, where he took the degree of Bachelor of Arts in 1903. For nearly 28 years, until his death, he was a member of the faculty of Armour Institute of Technology in the department of mathematics, holding successively the positions of instructor, assistant professor, associate professor, and eventually professor of mathematics, head of the department, and dean of students.

A profound student of mathematical theory, he was especially interested in the history and the early literature of the science. He was the author of a notably successful series of textbooks titled Practical Mathematics, and of five texts of college grade, in several of which he collaborated with other members of the faculty of the Institute.

Dean Palmer was a member of the American Mathematical Society, the Mathematical Association of America, the American Association for the Advancement of Science, and the Society for the Promotion of Engineering Education; and of the University Club of Chicago, the Armour Faculty Club, the Midway Athletic Club, and the National Arts Club of New York. He was an elder of the First Presbyterian Church of Chicago.

A just and a kindly man, Dean Palmer had great ability as a teacher, and exceptional qualifications as a guide and a friend to students. His memory will long remain in the minds of his colleagues.

A. J. WOOD

A. J. Wood, Head of the Mechanical Engineering Department at Pennsylvania State College, was struck by a motorcycle in front of his home about noon Saturday, April 18, and died in the Centre County Hospital at Bellefonte about five hours later.

Arthur Julius Wood was born September 3, 1874, in Newark, N. J., of deVolson Wood and Frances (Hartson) Wood. His father was a professor of thermodynamics at the University of Michigan and, later, of mechanical engineering at Stevens Institute of Technology, and was well known in his day and profession as an engineer, writer and teacher. Prof. Wood came from New England ancestry.

He was graduated from Stevens Institute with the degree of Mechanical Engineer in 1896 and for the four years immediately thereafter was associate editor of the *Railroad Gazette*. From 1900 to 1902 he was an instructor in Worcester Polytechnic Institute, and went from there to Delaware College as Professor. He came to Penn State in 1904 with his wife Helen M. Kerr, whom he had married that same year. From that time until 1908 he was assistant professor of experimental engineering, being promoted to associate professor and holding that rank to 1910, when he was made associate professor of railway mechanical engineering. In 1918 he was made Professor of Railway Mechanical Engineering and in 1922 was made head of the department of mechanical engineering with a full professorship. For three years, from 1919 to 1922, he was in charge of the Thermal Plant of the Engineering Experiment Station.

His contributions to the literature of engineering fall in the categories of heat transmission, railway mechanical engineering, and refrigeration. He published one textbook, on "Locomotive Operation and Train Control," and was the author of about fifty monographs, bulletins and articles on the above-mentioned subjects.

He was president of the American Society of Refrigerating Engineers during their 25th anniversary year, 1929; had served the American Society of Mechanical Engineers on their committee on heat-transfer, and also as chairman of the local (Central Pennsylvania) section, in 1922. He was also a member of the American Railway Association (mechanical Division), of the Society for the

Promotion of Engineering Education, a fellow of the American Association for the Advancement of Science, honorary member of Sigma Tau fraternity, member of the honorary engineering fraternity, Pi Tau Sigma.

His contribution to the teaching of mechanical engineering consists in the formulation of the course of study, in the building up of a staff of instructors devoted to him and working smoothly together, and in turning out a body of alumni who have been quite uniformly successful.

BOOK REVIEW

Principles of Engineering Thermodynamics. BY PAUL J. KIEFER, Professor of Mechanical Engineering, U. S. Naval Post Graduate School, and Milton C. Stuart, Professor of Experimental Mechanical Engineering, Lehigh University. John Wiley and and Sons, Inc., New York. 545 pages. Price $4.50.

Whatever relevancy a new book on engineering thermodynamics may have to immediate problems and developments in engineering practice, its success as a textbook will depend principally upon the clarity of its exposition of the first and second laws of thermodynamics, and the precision with which it traces understandingly the implications of these laws and their practical consequences. In this respect, "Principles of Engineering Thermodynamics" by Kiefer and Stuart is a fortunate contribution. It is pertinent to practice. But of more importance, it clarifies fundamental theory.

One need not be in immediate accord with the complete terminology employed by the authors to recognize that in their insistence upon exactness and consistency lies one principal reason for their success in simplifying the explanation of practical processes, and no small part of the educational value of the book. A clear distinction is drawn between energy stored in a system and energy in a state of transition. Heat and work are forms of the latter, potential and kinetic energy are forms of the former. Entropy is described as an index of the unavailability of energy. The term heat content is discarded and the term enthalpy is substituted.

Parts I and II deal with energy and the availability of energy. Subsequent chapters deal with the properties of liquids and vapors; gases and gas-vapor mixtures, including humidity and hygrometry; nozzles, orifices, diffusers, ejectors, etc.; steam power plant cycles, such as the Rankine cycle, the regenerative cycle, the reheat-regenerative cycle, and binary vapor cycles; the reciprocating engine; the steam turbine; combustion; internal combustion engines; compressors and blowers; refrigeration, and general thermodynamic equations.

The book will reward the serious student capable of sustained concentration and close reading.

L. H.

INDEX TO VOLUME XXI, JOURNAL OF ENGINEERING EDUCATION

ADDITIONAL NEW MEMBERS

BABBITT, ARTHUR B., General Manager, Kent Machine Works, Earl Ave., Kent, Ohio. W. W. Edwards, C. W. Banks, F. E. Dobbs.

BENNER, J. ALFRED, Assistant Professor of Mathematics, Lafayette College, Easton, Pa. D. A. Hatch, E. H. Rockwell.

BENNETT, CLAUDIUS E., Acting Associate Professor of Electrical Engineering, University of North Carolina, Chapel Hill, N. C. E. W. Winkler, John E. Lear.

BLOSSOM, FRANCIS, Civil Engineer, Sanderson & Porter, 52 William St., New York City. Gano Dunn, Charles F. Coun, F. L. Bishop.

BOURDELAIS, GEORGE A., Instructor in Engineering, Swarthmore College, Swarthmore, Pa. Chas. G. Thatcher, Scott B. Lilly.

BOWMAN, JAMES H., Instructor in Electrical Engineering, Purdue University, Lafayette, Ind. D. D. Ewing, C. F. Harding.

BRADLEY, JAMES A., Associate Professor of Chemical Engineering, Dean, Newark College of Engineering, Newark, N. J. V. T. Stewart, F. L. Bishop.

BROWN, HAROLD W., Consulting Engineer, 1437 Rugby Road, Schenectady, N. Y. Ernest E. Johnson, Carrol G. Brown.

CHEATHAM, JAMES C., Instructor in Mechanical Engineering, A. & M. College of Texas, College Station, Texas. C. W. Crawford, V. M. Faires.

HASKINS, GEORGE W., Associate Professor of Aeronautical Engineering, Purdue University, Lafayette, Ind. H. L. Solberg, J. D. Hoffman.

JENNESS, LESLIE G., Instructor in Chemical Technology, Pratt Institute, Brooklyn, N. Y. S. S. Edmands, Allen Rogers.

MARIN, JOSEPH, Instructor in Civil Engineering, Rutgers University, New Brunswick, N. J. P. H. Daggett, A. R. Johnson.

PENRIQOY, ROBERT L., Director of Engineering, Professor of Civil Engineering, Texas College of Arts and Industries, Kingsville, Texas. F. C. Bolton, F. E. Giesecke.

RAMSAY, JOSEPH W., Associate Professor of Electrical Engineering, University of Texas, Austin, Texas. J. A. Correll, E. C. H. Bantel.

REINSCH, BERNHARD P., Professor and Head, Department of Mathematics, Southern Methodist University, Dallas, Texas. E. H. Flath, R. D. Campbell.

RICE, ANDREW C., Instructor in Chemical Technology, Pratt Institute, Brooklyn, N. Y. S. S. Edmands, Allen Rogers.

SHORT, BYRON E., Adjunct Professor of Mechanical Engineering, University of Texas, Austin, Texas. A. Vallance, C. Eckhardt.

STONE, RALPH B., Associate Professor of Mathematics, Registrar, Purdue University, Lafayette, Ind. C. F. Harding, R. B. Wiley.

TROFIMOV, LEV A., Development Engineer in charge of Research and Development Department, Electric Controller and Manufacturing Co., Cleveland, Ohio. E. S. Foster, F. L. Bishop.

WHELAN, DANIEL E., JR., Professor of Civil Engineering, Loyola University at Los Angeles, Calif. D. M. Wilson, G. H. Dunstan.

216 new members, May 29, 1931.